

CANAL CONNECTING LAKES UNION, SAMAMISH, AND
WASHINGTON WITH PUGET SOUND, WASHINGTON.

L E T T E R

FROM

THE ACTING SECRETARY OF WAR,

TRANSMITTING

A report of the Board of Engineers upon a location and cost of a ship canal to connect Lakes Union, Samamish, and Washington with Puget Sound, Washington, made in compliance with act of September 19, 1890.

JANUARY 5, 1892.—Referred to the Committee on Rivers and Harbors and ordered to be printed.

WAR DEPARTMENT,
Washington, January 2, 1892.

SIR: I have the honor to inclose herewith a letter from the Chief of Engineers, dated December 30, 1891, together with a copy of a report from a Board of Engineers consisting of Col. G. H. Mendell, Maj. T. H. Handbury, and Capt. T. W. Symons, Corps of Engineers, dated December 15, 1891, upon a location and estimate of cost of a ship canal to connect Lakes Union, Washington, and Samamish with Puget Sound, Washington, made in compliance with the provisions of the river and harbor act of September 19, 1890.

Very respectfully,

L. A. GRANT,
Acting Secretary of War.

The SPEAKER OF THE HOUSE OF REPRESENTATIVES.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., December 30, 1891.

SIR: I have the honor to submit herewith report dated December 15, 1891, with map, upon location and estimate of cost of a ship canal to connect Lakes Union, Washington, and Samamish with Puget Sound, Washington, made by the Board of Engineers constituted in compliance with provisions of river and harbor act approved September 19, 1890.

A canal connecting Lakes Samamish and Washington, with a lock near Lake Washington to overcome the difference—10.5 feet—in the level of the two lakes, is estimated to cost \$4,927,230.

The proposed route and project for a canal connecting Lake Washington with Puget Sound contemplates constructing a canal 2,600 feet long, 80 feet wide at bottom and 158 feet wide at the water line, and 26 feet deep through the portage between Union Bay, in Lake Washington, and Lake Union, with a masonry lock 400 feet long, 50 feet wide, 26 feet deep over sill, and with a lift of about 7.5 feet; dredging channels to connect this canal with deep water in Lake Washington, and across Lake Union; and constructing a canal 6,700 feet long, 80 feet wide at bottom and 158 feet wide at the water line, and 26 feet deep, connecting Lake Union along its outlet with the head of Salmon Bay. From the head of Salmon Bay to Puget Sound two routes are considered by the Board; one by way of Salmon Bay and Shilshole Bay, with a lock near the Sound 400 feet long, 50 feet wide, and 16.6 feet deep over sill at low tide; the other by way of Smiths Cove and a canal 80 feet wide at bottom, 158 feet wide at the water line, and 26 feet deep, to be constructed across the neck of land between the head of Salmon Bay and Smiths Cove with a lock near the Sound similar to that projected for Shilshole Bay. The construction of a basin and formation of a channel through the shoals at the outlet of the lock are also contemplated. The estimated cost of the proposed canal between Lake Washington and Puget Sound by the two routes, not including damages for lands submerged, is as follows:

Smith Coves route	\$3,500,000
Shilshole Bay route	2,900,000

Concerning the comparative advantages of the two routes the Board states:

The Shilshole Bay system costs \$600,000 less than that by Smiths Cove. On the other hand, the latter route possesses advantages in that its entrance is in the harbor of Seattle, whereas the entrance to the other is $5\frac{1}{2}$ miles distant; and secondly, the Smiths Cove entrance and lock are less exposed to bombardment by an enemy's fleet. For these reasons the Smiths Cove route is to be preferred.

Very respectfully, your obedient servant,

THOS. LINCOLN CASEY,
Brig. Gen., Chief of Engineers.

Hon. L. A. GRANT,
Acting Secretary of War.

REPORT OF BOARD OF ENGINEERS ON PROPOSED SHIP CANAL TO CONNECT LAKES UNION, WASHINGTON, AND SAMAMISH WITH PUGET SOUND, WASHINGTON.

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, December 15, 1891.

GENERAL: The Board appointed under the act of Congress of September 19, 1890, to select and survey the most feasible location and to estimate the expense of construction of a ship canal to connect Lakes Union, Washington, and Samamish with the waters of Puget Sound, having completed that duty, has the honor to submit the following report:

The Board visited Seattle and carefully examined the vicinity of all the feasible routes for the prescribed canal, and determined the char-

acter and extent of surveys and investigations which would be required for a complete understanding and discussion of the problem involved.

A public meeting was held at the rooms of the Seattle Chamber of Commerce, at which citizens and other interested parties expressed orally their views upon the canal and its various features.

Written communications received by the Board appear as appendixes to the report.

The Board designated Capt. Thomas W. Symons as disbursing officer and as executive in charge of the surveys and preparation of the plans.

The services of Mr. Philip G. Eastwick, civil engineer, were secured, and he was placed in charge of the surveys, with headquarters at Fremont, a suburb of Seattle. Mr. Eastwick's report is herewith.

Accompanying this report is a general map upon a scale of 1 inch to $1\frac{1}{2}$ miles, showing the vicinity of Seattle with Lakes Union, Washington, and Samamish, in their relation to Puget Sound. Upon the same sheet is a map, illustrating in greater detail the canal survey from Puget Sound to Lake Washington, upon a scale of 1 inch to 400 feet, and longitudinal profiles and cross sections along the selected canal routes.

GENERAL DESCRIPTION.

The city of Seattle, the largest city of the State of Washington, is situated upon Duwamish or Elliott Bay, an indentation of the easter shore of Puget Sound, about half way between the upper or southern end and its junction with the Strait of Juan de Fuca.

In the immediate vicinity of Seattle are the three lakes, Union, Washington, and Samamish, and also Salmon Bay and Smiths Cove, two arms of Puget Sound situated on the line of the projected canal.

LAKE UNION.

Lake Union, which is nearest to the heart of Seattle and to the Sound, is the smallest of these lakes. It has an area of 905 acres, of which 499 acres cover a depth of 25 feet, and with a maximum observed depth of 60 feet. The area of the drainage basin of this lake is 6 square miles.

This lake receives, in addition to the supply of water from its drainage basin, a considerable supply from Lake Washington, through a canal which has been cut through the divide separating the two lakes, and which is used for the passage of saw logs and small vessels.

The outlet of Lake Union is a small stream running from its extreme western end into Salmon Bay. The distance between the lake and the bay is 5,700 feet.

The general and average elevation of the surface of the water in Lake Union is 25.5 feet above extreme low water in Puget Sound, or 7.8 feet above extreme high water.

LAKE WASHINGTON.

Lake Washington, the largest of the three lakes, lies directly east of Lake Union and of Seattle. It is 19 miles long, averages about 2 miles in width, and has an area of 38.9 square miles, or 24,896 acres, of which probably 22,000 acres cover a depth of 25 feet or more.

The depth of this lake is very great. Soundings were not made over the entire area of the lake, but it is stated on apparently creditable

authority that depths of 600 feet have been observed. The deepest water observed was 150 feet, the length of the sounding line used.

The area of the drainage basin of the lake is 182 square miles. It receives, in addition, the drainage of the basin of Samamish Lake and river, the areas of which amount to 211 square miles.

The outlet of the lake is Black River, which unites with White River 2.5 miles below the lake, forming the Duwamish River. The Duwamish River follows a tortuous course for about 14 miles and empties into Duwamish Bay. A short distance below the outlet of the lake the Cedar River joins the Black River and flows with it to the Duwamish, except in times of flood in Cedar River, when the waters of Cedar River run partly into Lake Washington, which thus acts as a safety valve to prevent excessive flooding of the Duwamish River valley.

The general elevation of the surface of the lake is 33 feet above extreme low water in Puget Sound, or 15.3 feet above the highest tides. It is 7.5 feet above that of Lake Union.

The most extensive shoals of Lake Washington, where the water has a depth of less than 25 feet, are at the head and at the foot of the lake and in Union Bay. That at the head of the lake, formed by the deposition of sediment brought down by the Samamish River, covers an area of about 300 acres. That at the foot of the lake is evidently formed by the deposition of sediment brought down Cedar River during floods, when a large volume of the waters of that river is emptied into the lake. The area of this shoal is about 300 acres.

The shoal in Union Bay covers an area of 610 acres, almost the entire area of that bay.

The localities of the remaining shoals and their areas, are as follows:

	Aeres.
Juanita Bay, north of Kirkland, about.....	150
Three indentations, south of Houghton, about	200
Meydenbauer Bay, about.....	75
Mercer Slough Bay, about	200
Island Shoal, about	25
Waterworks Bay, about	25

LAKE SAMAMISH.

Lake Samamish lies to the east of Lake Washington and is separated from it by high ridges. It is about $7\frac{1}{4}$ miles long, with an average width of a little over 1 mile. The area of the lake is 8 square miles, and that of its drainage basin 102 square miles. Its outlet is through the Samamish River, which, 17 miles in length, flows through a swampy valley into Lake Washington. The observed elevation of the surface of this lake is 41.2 feet above low water in Puget Sound, or 9.6 feet above that of Lake Washington.

The fluctuations of the surfaces of these lakes are moderate and are elsewhere described.

SALMON BAY.

Salmon Bay is an estuary connecting through Shilshole Bay with Puget Sound.

In these bays the tide has a mean range of about 11 feet and an extreme range of nearly 18 feet.

At extreme high tide the level of Salmon Bay is 7.8 feet below the usual level of Lake Union.

This bay has not sufficient depth, even at high stage of tide, for the passage of vessels of considerable draft.

It will be seen hereafter that the recommended projects provide that the level of the water of Salmon Bay be raised to and maintained at the level of Lake Union, 7.8 feet above extreme high tide. This will necessarily cause the shores of Salmon Bay to be permanently submerged. Part of the submerged land, particularly in the town of Ballard, is occupied by buildings and wharves.

While the raising of the level of Salmon Bay must, to a very large degree, increase values of riparian lands by making a deep-water harbor, yet the submergence of certain lands gives rise to damages and loss, the particular dimensions of which have not been ascertained by the Board. These constitute a liability which is not embraced in the estimates.

The proper disposition of material excavated from the canal prism and from the bays and lakes by dredging, in raising these submerged lands, will be a factor in reducing considerably the measure of these damages.

CANAL TO LAKE SAMAMISH.

By its orders, the Board was directed to include in its survey and estimates, a section of canal connecting Lake Washington with Lake Samamish. It early became evident, however, that there was no real demand for this canal or expectation that it would be given serious consideration. Its cost has been ascertained by survey to be much greater than the cost of the portion connecting Puget Sound with Lakes Union and Washington, and the advantages to be derived from it are very small.

In the general consideration of the subject, therefore, the attention of the Board was, for the reason above stated, more particularly confined to the section connecting Lakes Union and Washington with Puget Sound.

ROUTES.

There are five possible routes for a canal connecting Lakes Union and Washington with Puget Sound.

First. By way of Duwamish Bay and the valley of the Duwamish and Black rivers to Lake Washington and across the Portage from Lake Washington to Lake Union.

Second and third. By way of depressions between the southern part of Lake Union and Duwamish Bay. (These routes were considered twenty years ago by Gen. Barton S. Alexander, and are known in his report as the "Mercer farm route" and the "Tramway route.") Thence from Lake Union to Lake Washington by a canal through the Portage.

Fourth. By way of Shilshole Bay, Salmon Bay, the valley of the outlet of Lake Union to Lake Union, and thence between Lakes Union and Washington, by a canal through the Portage.

Fifth. By way of Smiths Cove to the upper end of Salmon Bay; thence as in the preceding route.

The first route, by the valley of the Duwamish, was soon eliminated from serious consideration by its great cost and other disadvantages.

The second and third routes were practicable twenty years ago, when Seattle was a straggling village, but the land traversed by these routes is now built up with business blocks and residences and the cost of the right of way is prohibitory.

The fourth and fifth routes are entirely feasible. They have received full consideration, and estimates of cost by both routes are submitted.

These two routes coincide in alignment from Lake Washington to

Salmon Bay; they differ in that one makes the connection with Puget Sound from the head of Salmon Bay, by the lower end of Salmon Bay and Shilshole Bay, and the other through a low gap to Smiths Cove and Duwamish Bay.

In each of the projects, by Shilshole Bay or by Smiths Cove, vessels are to pass from the waters of Puget Sound to Salmon Bay through a masonry lock placed close to the sound, having a lift varying according to the stage of the tide.

The dimensions of the lock are as follows: Length, 400 feet; net width, 50 feet; depth on the sill at extreme low stage of tide, 16.6 feet.

These dimensions have been the subject of careful consideration in the way of adapting them, at a minimum cost, to present requirements of navigation and to those of the next few years.

The depth on the sill at the lowest high water is 26 feet, so that even in the lowest class of tide there will be two occasions in each twenty-four hours when vessels of 26 feet draft may pass through the locks.

As lower high waters are generally followed by higher low waters, which are but little lower than the preceding high water, there will generally be two or three hours at each high water during which vessels of this draft can pass the locks. The periods for passage of deep-sea vessels of ordinary draft (22 or 23 feet) will last from about half tide on the flood to half tide on the ebb, an interval, including both tides of the day, equal to twelve to fifteen hours. During the remaining portion of the day the lock will pass only vessels of less draft than 22 feet, but at all times there will be an opportunity to lock vessels of 16 feet draft.

This arrangement, which now appears to the Board to afford all needed facility with a minimum of expense, may require to be modified under further consideration of increasing commerce. The sill can be lowered at any time preceding construction, and any desired degree of accommodation can be secured by an increase of cost, which, being confined mainly to the cost of the lock, need not be very great.

As before stated, both projects provide that Salmon Bay shall be raised and maintained to the level of Lake Union.

Both projects include channels excavated through the shoals outside of the tidal locks, 300 feet wide and 26 feet deep at the lowest high tide, that through Shilshole Bay one-half mile and that at Smiths Cove one-third mile long, and basins at the outlets of the locks 500 feet long and 26 feet deep at extreme low tide, in which vessels may lie to await lockage.

The Shilshole Bay project provides for dredging a channel through Salmon Bay to a point common with the Smiths Cove route.

The Smiths Cove project embraces a canal 80 feet wide on the bottom, 158 feet wide at the water line, and 26 feet deep through the gap between the outer lock and Salmon Bay, and dredging through Salmon Bay to the same common point at its head.

The following features are common to both projects, viz:

A canal 6,700 feet long, 80 feet wide on the bottom, 158 feet wide at the water level, and 26 feet deep, connects the head of Salmon Bay with Lake Union.

This channel is extended through the shoal portions of Lake Union, 200 feet wide, to the portage which intervenes between Lakes Union and Washington. Through this portage a canal 2,600 feet long, 80 feet wide on the bottom, 158 wide at the water line, and 26 feet deep connects Lake Union with Union Bay, a shoal bight in Lake Washington. A lock 400 feet by 50 feet, with a lift of about $7\frac{1}{2}$ feet and depth on sill of 26 feet, overcomes the difference of level between the two lakes, and

a dredged channel 4,600 feet long through Union Bay completes the connection with deep water in Lake Washington.

In addition the Smiths Cove project requires a dam at the narrows of Salmon Bay which shall serve to raise its level to the required height.

The estimated cost of the Shilshole Bay system with masonry locks is \$2,900,000, and of the Smiths Cove route \$3,500,000.

The Shilshole Bay system costs \$600,000 less than that by Smiths Cove. On the other hand, the latter route possesses advantages in that its entrance is in the harbor of Seattle, whereas the entrance to the other is $5\frac{1}{2}$ miles distant, and, secondly, the Smiths Cove entrance and lock are less exposed to bombardment by an enemy's fleet. For these reasons the Smiths Cove route is to be preferred.

By either of these routes there will be added to the commercial facilities of Seattle three fresh-water areas where timber wharves can be constructed and cheaply maintained and where vessels can lie in perfectly quiet water of a constant level.

In the sound at Seattle the tide has an average range of more than 11 feet and an extreme range of nearly 18 feet. These oscillations of level are all embarrassing to commerce, and wooden wharves are liable to be destroyed by the teredo in a few months. Marine insects are very destructive to piling and other timber placed in the waters of Puget Sound.

Salmon Bay, maintained at the level of Lake Union, will contain 35 acres of water area more than 25 feet deep, and an additional area of 165 acres can be brought to the same depth by a moderate amount of dredging.

Lake Union has an area of 499 acres of a depth of 25 feet, which can if desirable be increased by dredging. The total area of the lake is 905 acres.

These two areas combined about equal the total area of the docks of London, and they can readily be made equal by dredging to the area of the Liverpool docks.

Lake Washington area contains 38.9 square miles, or about 25,000 acres, of which about 22,000 acres are covered with a greater depth of water than 25 feet.

In all essential respects the extension from Lake Washington to Lake Samamish conforms to the dimensions of the canal and locks below, connecting Lakes Washington and Union with Puget Sound.

In fixing upon the dimensions of the canal and locks the Board has endeavored to provide accommodation for the present and immediately prospective demands of commerce, and to so leave matters that, if in the future greater accommodations should be required, they can be added without interfering with the usefulness of the present proposed works. The locks are designed to pass the largest type of ships which visit Puget Sound. A list of this shipping, as far as could be ascertained, is here given.

STEAM VESSELS.

Name.	Length of keel.		Beam.		Draft.	Tonnage.
	<i>Ft.</i>	<i>In.</i>	<i>Ft.</i>	<i>In.</i>	<i>Feet.</i>	
San Pedro	331	3	42	2	20	3,300
Umatilla	310		40	6	21	2,800
Walla Walla	310		40	6	21	2,300
Willamette	315		39	2	21	2,300
Queen of the Pacific	331		38	5	22	1,800
City of Puebla	320	6	38	6	23	3,000
City of Topeka	198		35	3	17	1,000
Haytien Republic	191	5	36	1	16	875
Al-ki	200	1	38	2	17	1,800

For extreme length, from 10 to 30 feet must be added to the length of keel noted, and for extreme width 1 foot must be added to the beam. Heights from the water line to tops of masts will range from 120 to 150 feet.

SAILING VESSELS.

Name.	Length of keel.		Beam.		Draft.	Tonnage.
	<i>Ft.</i>	<i>In.</i>	<i>Ft.</i>	<i>In.</i>	<i>Feet.</i>	
Spartan.....	207	6	40	5	22	2,200
Ivanhoe.....	202	3	39	3	23	2,200
Germania.....	170	2	36		19	1,600
Templar.....	155		35	2	19	1,600
Blue Jacket.....	193	8	45		21	1,800
Detroit.....	197		38	5	22	2,200
Levi G. Burgess.....	217	5	41	2	22	2,500
Alexander McNeill.....	174	4	36	6	20	1,500
Margaret.....	201		39	1	23	1,500
Highland Light.....	194	9	38	1	23	1,900
Commodore.....	226	9	41	8	24	3,000
Abner Coburn.....	225		43	2	26	3,300
Elizabeth.....	231	5	41	8	26	3,100
Alexander Gibson.....	247	5	42	6	27	3,300
J. B. Walker.....	247	1	42	2	27	3,300
Daniel I. Tenny.....	212	4	40	4	24	2,200
Undaunted.....	207	3	41		23	3,000
Edward O'Brien.....	259	1	42	2	27	3,000
T. F. Oakes.....	264	6	42	2	24	2,800
Gen'l Fairchild.....	203	4	38	8	23	2,400

For length "over all" from 30 to 45 feet must be added to the length of keel noted, and for extreme width 1 foot must be added to the beam. Heights from the water line to top of masts will range from 150 to 200 feet. Top masts can be so lowered as to reduce this height 30 to 40 feet.

From these lists it is seen that all the steamships are readily accommodated, and that all the sailing ships can be accommodated as far as length and width are concerned, and generally with a tug in the same lockage. There are a few ships noted that when fully loaded draw 27 feet.

As the tendency in modern ship building is toward steamships and sailing vessels of smaller draft, it was not deemed necessary to provide at present for the few wooden sailing ships of excessive draft.

There are two classes of ships which can not be passed through the proposed lock, "ocean greyhounds," similar to those plying on the Atlantic, which would be debarred on account of their great length, and the large first class battle-ships and protected cruisers of the Navy, which would be debarred on account of their great breadth of beam. To these may be added the large side-wheel steamers engaged in local traffic on Puget Sound, of the type of the *Olympian*, which is 75 feet wide, guard to guard.

If future developments shall show the desirability of providing for the passage of such shipping, other locks can be built of size sufficient to afford the required accommodation.

The ideal arrangement for this canal would be that laid down for the Manchester Ship Canal, where three locks are planned side by side, one 80 by 600 feet, one 50 by 350 feet, and one 30 by 175 feet.

WATER SUPPLY.

Lake Washington furnishes an ample water supply for the service of the canal.

As it is probable that the lower lock will be used much more fre-

quently than the upper lock, and as the latter at each lockage passes less water than the former, it is necessary to provide for the passage from Lake Washington to Lake Union of the additional amount of water required for the lower lock. Proper weirs for this purpose are provided at the upper or Portage Lock. If future developments should show the necessity for more water than can well be taken from Lake Washington, an additional supply can be obtained by turning the water of Cedar River into the lake. This can be done at a comparatively small expense.

MODIFICATIONS.

Various modifications of the plan finally fixed upon were considered by the Board of Engineers.

Principal among these was the project of bringing Lakes Union and Washington to the same level, and avoiding thereby a lock at the portage.

Three ways of doing this are available: By lowering Lake Washington to the level of Lake Union; by raising Lake Union to the level of Lake Washington, or by establishing a common intermediate level by raising one and lowering the other.

Upon a full consideration of the advantages and disadvantages which these modifications presented, it was concluded that, owing to the disturbance they would make in values along the shores of the lakes, and to the consequent damages, the best plan would be to leave the lakes at their present levels and connect them by a lock.

Another modification consisted in putting in the outer lock at the head of Salmon Bay and dredging thence a channel through Salmon and Shilshole bays to the deep water of the Sound; but this would largely increase the excavation required, and the project would be deprived of the great benefit of the fresh-water basin of Salmon Bay. This is a modification which might well be considered, however, if the question of damages at Ballard and elsewhere along Salmon Bay can not be satisfactorily solved.

If, in the Smiths Cove route, the question of damages arising from raising and maintaining permanently the waters of Salmon Bay at the level of Lake Union be not capable of satisfactory adjustment, the lower part of that bay, where the greater amount of damages would accrue, can be left in its present condition, and the canal be carried through from the outer lock to the Fremont Cut and Lake Union, and be separated from the lower part of Salmon Bay, in its passage through the head of that bay, by an embankment.

A modification was also considered of substituting for masonry locks locks composed partly of masonry and partly of timber. If this were done, there would be a saving of \$276,000 in the cost of the outer lock, whether situated at Smiths Cove or Shilshole Bay, and a saving of \$253,000 in the cost of the lock at the portage between Lakes Union and Washington.

In the project for the section of canal connecting Lakes Washington and Samamish, it is designed to carry the level of Lake Samamish through the canal to a lock placed near Lake Washington, to overcome the difference of 10½ feet, and to make the canal partly in cut and partly in embankment. This project would have to provide for the drainage of Lake Samamish through the canal. The valley of the Samamish River is occupied by the Seattle, Lake Shore and Eastern Railway, and contains 2,180 acres of valuable land, the surface of which

is below the level of Lake Samamish. To drain this valley independent low-water channels would have to be provided.

By placing a dam near the lock at the outlet of the valley, and dispensing with the independent drainage channels, the low lands of the valley would be flooded.

The disturbance of values and resultant damages due to the flooding of the valley would largely exceed the cost of drainage by the independent channels.

As the building of this section of canal has not been seriously contemplated, the time and care applied to making the plans and estimates for it have not been as great as to the other portion from the Sound to Lake Washington.

The project of the Board contemplates the raising of the waters of Salmon Bay to the level of Lake Union, 7½ feet above the extreme high tide level, and permanently maintaining them at this elevation. This will flood an area of 187 acres above high tide, by far the greater part of which is about the head of Salmon Bay, above the town of Ballard.

There are some improvements about the town of Ballard which will be interfered with by this raising of the water, and the estimates include the necessary work required to raise the buildings, mills, etc., so interfered with.

It is proposed to utilize to as great an extent as possible the material excavated from canal and channels in filling up to the necessary level the lands overflowed.

No other provision is made for these lands, as it is believed that the great additional value given to them by the construction of the canal, basins, etc., would more than compensate the owners for the trouble and expense which they might be put to in raising them to proper grade.

It is proposed to make, as previously stated, the channel from the outer lock to deep water in the Sound 300 feet wide and 26 feet deep at the lowest high water.

No provision is made for maintaining this channel, as it can only be definitely ascertained by experience whether any works of maintenance will be required.

If it be found, after the canal is put in operation, that this channel shoals up, it can be maintained either by dredging or by building jetties to exclude drift, or by both.

ESTIMATES.

The projects contemplate the construction of masonry locks, each provided with an upper and a lower lock-gate and a guard-gate, all constructed of steel, with all necessary capstans, and inlet and outlet valves, with hydraulic engines to operate them, the power to be supplied by turbine wheels; with dwelling houses for keepers; with electric lighting plant for lighting the lock; with stone revetted wasteweirs, etc.

The canal proper in upland cuts is to have a bottom width of 80 feet and a surface width of 158 feet; the channels in Salmon Bay, Lake Union, and Union Bay are to have bottom widths of 200 feet, and the approach from deep water in the Sound to the outer lock is to be 300 feet wide.

Smiths Cove route.—The total estimated cost of the complete project for the ship canal from deep water in Duwamish Bay, via Smiths Cove, the head of Salmon Bay and Lake Union, to Lake Washington, is \$3,448,261.23; in round numbers, \$3,500,000. This cost can be materially reduced in two ways:

First, by building, instead of a double-track canal in which ships can pass each other, a single-track canal in the three portions of the canal excavated in the uplands, namely, from the outer lock to Salmon Bay, from Salmon Bay to Lake Union, and from Lake Union to Lake Washington. The canal designed and for which the estimates are made is 80 feet wide on the bottom and 158 feet at the water line. By reducing the width at bottom to 50 feet and at the water line to 128 feet, ample provision would be made for the passage of ships from one basin to another and out to the Sound, and the additional width can be given when demanded by the increase of commerce.

In the same manner the excavated channels in Salmon Bay, Lake Union, and Union Bay could be reduced from 200 feet in bottom width to 150 feet without any immediate disadvantage and the greater width be provided for when demanded by the increase of commerce.

By thus reducing the width of the canal and basin channels a saving in excavation of 800,000 cubic yards can be made, equivalent to \$400,000, reducing the estimated cost of the work to \$3,100,000.

A second way of reducing the estimated cost would be by the substitution of composite locks of masonry and timber for masonry locks. In this way a saving of \$529,000 could be effected, still further reducing the cost to \$2,571,000.

Shilshole Bay route.—The total estimated cost of the complete project for the ship canal from deep water in Puget Sound via Shilshole and Salmon bays and Lake Union to Lake Washington is \$2,902,859.23, or in round numbers \$2,900,000.

As in the other case, the estimated cost of \$2,900,000 can be materially reduced in two ways.

First, by reducing the upland cuts from a bottom width of 80 feet to a bottom width of 50 feet, and the dredged channel through Salmon Bay, Lake Union, and Union Bay from 200 feet to 150 feet width at bottom.

This would reduce the amount of excavation to 670,000 cubic yards, equivalent to \$335,000, and the total estimated cost to \$2,565,000.

The second way of reducing the cost would be by substituting composite locks of masonry and timber for masonry locks. In this way a saving of \$529,000 could be effected, reducing the total estimated cost still further to \$2,036,000.

The estimates for both routes include the securing of sufficient land for the full width of canal.

The following is a summary of the estimates:

Smiths Cove route:

Double-track canal with masonry locks	\$3,500,000
Double-track canal with composite locks	2,971,000
Single-track canal with masonry locks	3,100,000
Single-track canal with composite locks	2,571,000

Shilshole Bay route:

Double-track canal with masonry locks	2,900,000
Double-track canal with composite locks	2,371,000
Single-track canal with masonry locks	2,565,000
Single-track canal with composite locks	2,036,000

The estimated cost of the canal to connect Lakes Washington and Samamish is \$4,927,230.

PHYSICAL DATA.

The following table gives in a convenient form the principal physical data connected with the project:

Elevations:

Extreme low tide, Puget Sound	feet..	0
Mean low tide, Puget Sound	do..	3.3
Lowest high tide, Puget Sound	do..	9.4
Mean high tide, Puget Sound	do..	13.6
Extreme high tide, Puget Sound	do..	17.7
Lake Union, lowest water observed above extreme low tide of Puget Sound	feet..	25
Lake Union, highest water observed above extreme low tide of Puget Sound	feet..	26.1
Lake Washington, lowest water observed above extreme low tide of Puget Sound	feet..	31.6
Lake Washington, highest water observed above extreme low tide of Puget Sound	feet..	33.1
Lake Washington, highest water flood marks above extreme low tide of Puget Sound	feet..	34.4
Lake Samamish, lowest water observed above extreme low tide of Puget Sound	feet..	41.2
Lake Samamish, highest water observed above extreme low tide of Puget Sound	feet..	43.1
Divide between Smiths Cove and Salmon Bay, above extreme low tide, Puget Sound	feet..	49
Portage Divide, between Lakes Union and Washington, above low water of Lake Washington	feet..	30
Divide on "Mercer Farm Route," above Lake Union	do..	108
Divide on "Tramway Route," above Lake Union	do..	105

Areas, depths, etc.:

Salmon Bay:		
Total water area	acres..	318
25 feet and over in depth	do..	35
Less than 25 feet in depth	do..	283
Lake Union:		
Total water area	do..	905
25 feet and over in depth	do..	499
Less than 25 feet in depth	do..	406
Greatest depth	feet..	60
Lake Washington:		
Total water area (about)	acres..	24,896
25 feet and over in depth (about)	do..	22,000
Greatest depth (probably)	feet..	600
Lake Samamish:		
Total water area	acres..	5,120
25 feet and over in depth (about)	do..	4,000
Less than 25 feet in depth	do..	1,120
Greatest depth (about)	feet..	100
Lake Union Drainage Basin	sq. miles..	6
Lake Washington Drainage Basin	do..	182
Samamish River Drainage Basin	do..	109
Lake Samamish Drainage Basin	do..	102

Distances:

Deep water to outer lock, Shilshole Bay (from 30-foot curves) ..	feet..	2,400
Deep water to outer lock, Smiths Cove (from 30-foot curves) ..	do..	2,000
Outer lock, Shilshole Bay to head Salmon Bay	do..	12,900
Outer lock, Smiths Cove to head Salmon Bay	do..	12,000
Head Salmon Bay to Lake Union, "Fremont Cut"	do..	4,800
Through Lake Union to upper lock	do..	13,300
Upper lock through Portage Canal to Union Bay and Lake Washington	feet..	3,100
Through Union Bay to deep water in Lake Washington	do..	4,600
Lake Washington to Lake Samamish	miles..	13
Samamish River, total length	do..	17
Lake Washington, down Black to Cedar River	do..	$\frac{1}{2}$
Lake Washington, down Black to White River	do..	$2\frac{1}{2}$
Duwamish River from junction of Black and White rivers to Duwamish Bay, length of valley	miles..	8
Duwamish River, length of river	miles..	14

Distances—Continued.

Outlet Duwamish River across tide flats to deep water	do...	1½
Diameter Union Bay	do...	1½
Duwamish Bay to Lake Union by "Mercer Farm Route"	feet..	5, 100
Duwamish Bay to Lake Union by "Tramway Route"	do...	6, 310

Dimensions:

Approach to outer lock, depth below lowest high water	feet ..	26
Approach to outer lock, width at bottom	do...	300
Outer lock:		
Width of gates, clear width	do...	50
Length of lock chamber, clear length	do...	400
Depth of lock, clear depth	do...	26
Lift of lock	do...	7.3-26.1
Lift of lock, average	do...	14.4
Channel in Salmon Bay, Lake Union, and Union Bay, depth	do...	26
Channel in Salmon Bay, Lake Union, and Union Bay, width at bottom	feet..	200
Canal excavated in uplands, Smiths Cove Cut, Fremont Cut, and Portage Cut, width at bottom	feet..	80
Canal excavated in uplands, Smiths Cove Cut, Fremont Cut, and Portage Cut, width at water line	feet..	158
Canal excavated in uplands, Smiths Cove Cut, Fremont Cut, and Portage Cut, depth	feet..	26
Upper lock, same dimensions as outer lock.		
Lift of upper lock, maximum	do...	8.1
Lift of upper lock, average	do...	6.6

Very respectfully, your obedient servants,

G. H. MENDELL,
Colonel, Corps of Engineers.
THOS. H. HANDBURY,
Major, Corps of Engineers.
THOMAS W. SYMONS,
Captain, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

REPORT OF MR. PHILIP G. EASTWICK.

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, September 14, 1891.

SIR: Under your instructions I have made surveys upon which to base a project, and estimates, for the construction of a canal to connect lakes Union, Washington, and Samamish with Puget Sound, as authorized by the river and harbor act of September 19, 1890, and respectfully submit the following report:

Accompanying this report is also submitted a sheet upon which is drawn to a scale of two-thirds of an inch to 1 mile, a general map showing the position of the lakes and their surroundings with reference to Puget Sound; and a map to a larger scale showing more in detail that part of the selected canal route between Lake Washington and Puget Sound.

On the general map are shown the respective drainage basins of the three lakes and of the Samamish River, the link connecting Samamish Lake with Lake Washington.

The following table shows the relative elevations of the surface of the water in the lakes and of the high and low water planes of Puget Sound, the plane of extreme low water, as deduced from observations extending over six weeks, being taken as the plane of reference.

		Feet.
Lake Samamish.....	Highest observed	43.1
	Lowest observed	41.2
Lake Washington.....	Highest flood marks	34.4
	Highest observed	33.1
	Lowest observed	31.6
Lake Union.....	Highest observed	26.1
	Lowest observed	25.0
Shilshole Bay	Extreme high tide	17.7
	Mean high tide	13.6
	Lowest high tide	9.4
	Mean low tide	3.3
	Extreme low tide	0.0

The basins of Lake Samamish, Samamish River, and Lake Washington together form one greater basin, having its outlet at the south end of Lake Washington through Black and Duwamish rivers to the waters of Puget Sound at the head of Duwamish or Elliott Bay.

This larger basin is separated from the basin of Lake Union and from Puget Sound on the west by a high ridge, with undulating surface, extending from Black River northward. Through this ridge is a low depression at a point where the shore lines of Lakes Washington and Union approach each other. At this place the width of the ridge is a little over one-third of a mile, and the greatest elevation 30 feet above the low-water plane of Lake Washington. Through this ridge, locally known as "The Portage," a narrow canal furnished with a lock has been made, and through this, in the operation of the canal, a small part of the water of Lake Washington is passed into Lake Union.

In the larger drainage basin, the sub-basins of Lake Samamish and of Samamish River are separated from that of Lake Washington by a high and broad ridge which terminates at its north end at the head of Lake Washington, where the Samamish River empties into that lake. Through this ridge no available canal route is offered. The only available route for a canal to connect these two lakes is through the valley of the Samamish River.

This valley is nearly thirteen miles long as measured on a practicable canal line. Owing, however, to the sinuosities of the river, its length is increased to seventeen miles.

The upper part of the valley is broad and flat and much of it so low as to be at all times marshy and frequently flooded. Descending toward Lake Washington, the valley narrows, and at three places, where the flanking hills throw out spurs into the low land, the thread of the valley is very abruptly deflected.

An extension shoal at the head of Lake Washington, through which a canal would pass, will increase the total length of the canal and its approaches to a little over 14 miles.

The Samamish River at low water is a stream of small velocity, averaging about 50 feet in width with a depth generally of from 6 to 8 feet. Near its head are a few reaches of rapid water passing over gravel bars where the depth is decreased to 3 feet in a narrowed channel.

Black River, the natural outlet to Lake Washington, joins with White River at a distance of $2\frac{1}{2}$ miles from the lake, the confluence of these two rivers forming the head of the Duwamish River. Black River passes generally through a contracted depression in the edge of a broad valley, receiving the waters of Cedar River about a half-mile below the outlet of Lake Washington. It carries the level of Lake Washington to near the junction of Cedar River, where, after receiving the waters of that river, it passes with a current of about 5 miles per hour during the low-water stage over a shoal and rocky bottom for a distance of over half a mile. Below this rapid a strong current continues to the head of the Duwamish. The river is from 50 to 150 feet wide.

Duwamish River flows in a very sinuous course through a broad flat valley to the head of Duwamish or Elliott Bay. On an air line between the head of the river and Duwamish Bay the distance is about 8 miles. By the sinuosities of the river, however, the distance is increased to 14 miles. The floor of the valley is low and flat, and subject in most parts to overflow during freshets. The repeated overflows have, by the deposit of sediment, raised the surface of the valley nearest to the river to an elevation higher than that of the more distant part near the base of the flanking hills, a slightly elevated river ridge having been formed.

From the outlet of Duwamish River, at the high-water line of Duwamish Bay, to deep water of the bay, there is a distance of $1\frac{1}{2}$ miles over a shoal mud flat, most of which is bare at low water.

It will thus be seen that the length of a canal from Lake Washington to deep water of Puget Sound will be at least 12 miles, with such increase as may be due to any obstructions to direct alignment that will upon definite survey be encountered.

With locks so located upon the line of the canal that the excavation would be a minimum, there would be at least 7,000,000 cubic yards of excavation for a canal prism having a width at bottom of 80 feet and at water surface of 160 feet, and carrying a depth of water of 26 feet.

But owing to the large volume of water which, at the time of floods, enters the Duwamish River from Cedar and White rivers, an enlargement of the canal to a very considerable magnitude would be required, that the current induced by the freshets would be reduced to a velocity that would not materially impede navigation or threaten destruction to the embankments of the canal; or such flood waters must be carried off in separate channels exterior to the canal prism.

Under any circumstances the volume of excavation would be largely increased over that stated. This increase would probably equal or exceed in quantity that of

the canal prism, making the total excavation for a canal by this route exceed 14,000,000 cubic yards.

Much of the excavation through the valley of the Black River (which, however, is a small part of the entire excavation) would be of rock. The large mass, however, of the entire excavation will probably be of easy-cutting sedimentary material.

White and Cedar rivers at the time of freshets carry down large amounts of gravel, sand, and mud, which, being deposited in the lower channel, will require to be periodically removed.

Without attempting to make a close estimate of the cost of a canal over this route, involving not only the excavation but also the construction of water-tight embankments throughout nearly the entire length of the canal, of one or more locks with a total lift of 34 feet, and of waste weirs, the compensation for land occupied, and other expenses incidental to the work, it may safely be assumed that the cost of construction and of maintenance will be so far in excess of that of a canal via Lake Union and Salmon Bay, and the benefits to commerce less advantageous, that the further consideration of this project is not warranted.

In the western shore of Lake Washington, nearly midway of its length, is an opening about 2,000 feet wide between low headlands leading into Union Bay. This bay is nearly circular in shape and about $1\frac{1}{2}$ miles in diameter. Its extreme western margin approaches the shore line of the eastern arm of Lake Union at a place heretofore referred to as "The Portage," where the divide is narrow and low. This place offers the only remaining possible canal outlet from Lake Washington in the direction of Puget Sound.

Union Bay is throughout nearly its entire extent very shoal, and has a bottom of soft ooze of considerable depth. A canal line through the bay would cut into this material for a length of 4,600 feet.

The canal cut through "The Portage" will be 2,600 feet long and the material, as indicated by the walls of the existing canal, will be cement, gravel, and hardpan.

In Lake Union, from the western end of "The Portage" cut to a depth of 26 feet, the distance is 5,600 feet. Near "The Portage" on this line the descent is abrupt to a depth of 18 feet at a distance of 700 feet. Over the remaining distance to 26 feet depth the bottom falls gradually with but little undulation.

The low-water level of Lake Washington is 6.6 feet higher than that of Lake Union. The flood marks of Lake Washington indicate a level 2.8 feet higher than the low-water level.

Between Lake Union and Puget Sound is a high ridge cut by a low and wide valley at the western end of the extreme western arm of the lake. Through this valley the natural drainage of the lake finds its outlet to the head of Salmon Bay, an arm of Puget Sound.

At the extreme south end of the lake are two depressions in the ridge separating the lake from Duwamish Bay. These depressions are referred to in the report of General Alexander, dated December 15, 1871, where they are designated as possible canal routes. They are in that report designated, respectively, as the "Mercer Farm Route" and the "Tramway Route." The distance between the lake and bay by the former route is 5,100 feet, and by the latter route, 6,310 feet, and the maximum elevations 108 and 105 feet respectively.

At the time of this first examination of these routes (nearly twenty years ago) the lands traversed by them was for the most part wild and unimproved, with an occasional clearing which added but little to its value. Much of the land in the vicinity was then, and remained for many years later, public land subject to entry under the homestead and preemption laws, not having sufficient value to attract the attention of settlers. The shores of the lake and bay at the termini of these routes were unimproved and unoccupied except by the cheaply constructed and temporary landings of the Seattle Coal and Transportation Company, who at that time operated a tramway over one of the routes in the transportation of coal, the need of which would have been obviated upon the construction of a canal. Seattle at that time was a village covering a very small area and having a population of about 1,200. It was surrounded by dense forests traversed by few wagon roads and trails.

According to the recent census the city of Seattle has a population of 45,953. The improvements of the city of Seattle now extend to, and far beyond, the location of these canal routes. Streets have been laid out, opened, and improved; costly manufacturing establishments, stores, warehouses, and dwellings have been erected, and the district changed to busy industrial adjuncts to Seattle, or to residential suburbs. The water fronts on Lake Union and on Duwamish Bay are occupied by industrial establishments, warehouses, and shipping wharves.

As a result, the value of the land traversed by these routes has during the past twenty years increased to figures of large proportions, and the conditions which warranted the consideration of a project for the construction of a canal over either of the routes are now so radically changed that the consideration of such a project may with

reason be abandoned in favor of the route via the valley of the natural outlet of the lake to the head of Salmon Bay.

The last named valley extends from Lake Union to the head of Salmon Bay, a distance of 6,700 feet. The floor of the valley is broad and low, its elevation at the upper end being but a few feet higher than the low-water level in Lake Union, and below that level at and near Salmon Bay. The entire area of the floor of this valley has been laid off into town lots upon which a few cheaply constructed buildings and a few sawmills have been erected, the removal of some of which will be required upon the construction of a canal.

To the north of this valley and of Salmon Bay the hills rise to a high and extensive undulating plateau. To the south lies Duwamish or Elliott Bay, separated by a high and broad plateau through which is a low, narrow, and straight gap connecting the head of Salmon Bay with Smiths Cove, an indentation in the north end of Duwamish Bay. Through this gap the distance is 5,000 feet between high-water lines and the maximum elevation, 49 feet above extreme low water of Puget Sound. In both Smiths Cove and Salmon Bay are extensive mud flats, bare at low water. Through this gap the lines of the Seattle, Lake Shore and Eastern Railway Company, and of the Seattle and Montana Railway Company, pass on their routes from Seattle to the north and east.

From its head Salmon Bay extends in a westerly direction a distance of 2 miles to Puget Sound, at the inner edge of Shilshole Bay, from whence the distance to deep water is nearly one-half mile over a sand beach, much of which is above the level of the low-tide plane.

Estimates of the cost of construction have been prepared for a canal connecting the lakes with Puget Sound, both on the routes from Shilshole Bay and from Smiths Cove to the head of Salmon Bay, and thence by a common route via Lake Union and "The Portage" to Lake Washington, and also from Lake Washington to Lake Samamish via the valley of Samamish River. These estimates are given in detail in the Appendix and are stated in their totals, as follows:

TOTALS OF ESTIMATES.

A. From Puget Sound to head of Salmon Bay:	
1. Via Shilshole Bay	\$1, 019, 319. 51
2. Via Smiths Cove	1, 564, 721. 51
B. From head of Salmon Bay to Lake Union:	
Via the valley of the outlet to the lake	506, 000. 00
C. From Lake Union to Lake Washington:	
Through "The Portage"	1, 122, 706. 75
D. From Lake Washington to Lake Samamish:	
Via the valley of Samamish River	4, 927, 230. 00
To these estimates of the cost of construction between Puget Sound and Lake Union, either via Shilshole Bay or Smiths Cove, must be added the estimated cost of changing the location of the Seattle, Lake Shore and Eastern and of the Seattle and Montana railways.	89, 832. 97
And of raising mills, dwellings, stores, etc., in the town of Ballard ...	165,000. 00

Detailed estimates of these are given in the Appendix.

In case of the construction of the canals by both the Shilshole Bay and Smiths Cove routes, \$27,500 should be deducted from the summary estimate for the cost of the dam at the narrows in Salmon Bay, which in that case will be omitted.

The foregoing estimates are summed up for different combinations as follows:

I.—Puget Sound to Lake Union.

a. Via Shilshole Bay:	
Puget Sound to head of Salmon Bay	\$1, 019, 319. 51
Head of Salmon Bay to Lake Union	506, 000. 00
Change of railway location	89, 832. 97
Raising mills, etc., in Ballard	165, 000. 00
Total	<u>1, 780, 152. 48</u>
b. Via Smiths Cove:	
Puget Sound to head of Salmon Bay	1, 564, 721. 51
Head of Salmon Bay to Lake Union	506, 000. 00
Change of railway location	89, 832. 97
Raising mills, etc., in Ballard	165, 000. 00
Total	<u>2, 325, 554. 48</u>

c. Via Shilshole Bay and Smiths Cove combined:

Puget Sound to head of Salmon Bay, via Shilshole Bay.....	\$1, 019, 319. 51
Via Smiths Cove.....	\$1, 564, 721. 51
Less cost of dam.....	27, 500. 00
	<hr/> 1, 537, 221. 51
Head of Salmon Bay to Lake Union	506, 000. 00
Change of railway location	89, 832. 97
Raising mills, etc., in Ballard.....	165, 000. 00
	<hr/>
Total.....	3, 317, 373. 99

Adding to each of these estimates the estimated cost of construction between Lakes Union and Washington, the following estimates are obtained:

II.—Puget Sound to Lake Washington.

a. Via Shilshole Bay.....	\$2, 902, 859. 23
b. Via Smiths Cove	3, 448, 261. 23
c. Via Shilshole Bay and Smiths Cove combined	4, 440, 080. 74

And if to these last estimates the estimated cost of construction between Lakes Washington and Samamish be added, the entire cost of the canal connecting Lakes Samamish, Washington, and Union with Puget Sound under the different projects is obtained as follows:

III.—Puget Sound to Lake Samamish.

a. Via Shilshole Bay.....	\$7, 830, 089. 23
b. Via Smiths Cove	8, 375, 491. 23
c. Via Shilshole Bay and Smiths Cove combined	9, 367, 310. 74

All estimates are based upon excavation through the higher lands of a canal prism having a cross section as shown on the accompanying map; the bottom of the canal to be 80 feet wide and side slopes $1\frac{1}{2}$ horizontal to 1 vertical up to the tow path or lower berme 32 feet above the bottom; the depth of water in the canal to be 26 feet. In the deeper excavation the slopes above the towpath or lower berme to be 1 horizontal to 1 vertical, with narrow bermes at each 20 feet of excavation.

Through Salmon Bay, interior to the outer locks and through the shoals in Lakes Union, Washington, and Samamish, and in Union Bay, the estimates contemplate the excavation of a channel 200 feet wide carrying 26 feet depth of water. Exterior to the locks of Salmon Bay and Smiths Cove the width of channel is increased to 300 feet, with a depth of 26 feet of water at the lowest high tide.

The locks at the outlet of the canal systems both at Salmon Bay and Smiths Cove are to be placed near to Puget Sound, raising the water in the canal between them and Lake Union to the level of the lake. Each of the locks will have a lift of 16.7 feet at low high water and 26.1 feet at extreme low water.

The lock at the Portage provides for a lift of 8.1 feet, the difference of level between the low-water level of Lake Union and the extreme flood level of Lake Washington. This lock is to be placed at the head of Lake Union and adjoining the excavation at the Portage.

The lock between the waters of Lakes Washington and Samamish provides for a lift of $10\frac{1}{2}$ feet, the difference of level between the low-water level of Lake Washington and the high-water level of Lake Samamish. Upon the excavation of the canal in the Samamish River Valley, a freer outlet of the waters of Lake Samamish will be offered, and the rise in that lake, which is caused by the present restricted channel, will be reduced, thereby lessening the lift required in the lock. This lock is located at the outlet of the river at the head of Lake Washington.

The projects contemplate the construction of masonry locks provided with an upper and a lower lock gate and a guard gate constructed of steel, all necessary capstans, inlet and outlet valves, and hydraulic engines to operate them, the power to be supplied by turbine wheels. The locks are to have a clear width of 50 feet at the gates and in the main lock prism, and a length to accommodate vessels 400 feet long.

Independent estimates have been made for all locks wherein the masonry has been, as far as practicable, replaced by structures of timber.

Substituting such structures, the cost of the respective locks will be reduced as follows:

	Difference in cost.
Lock at outlet at Salmon Bay.....	\$276, 000
Lock at outlet at Smiths Cove	276, 000
Lock at the Portage	253, 000
Lock at head of Lake Washington	271, 000

In the following table are given the lengths of the several reaches of canal on the route via Shilshole Bay, including the lengths of the intermediate reaches in Lakes Union and Washington, where no improvements are required.

	Miles.
From deep water of Puget Sound to head of Salmon Bay and point common with Smiths Cove Canal	2.84
Fremont Canal and approaches	1.02
Lake Union (no improvement required)	1.50
Portage Canal and approaches	2.42
Lake Washington (no improvement required)	8.25
Samamish Valley Canal and approaches	14.07

From these data the following table of lengths is deduced:

	Miles.
From Puget Sound to Lake Union	3.86
From Puget Sound to Lake Washington	7.78
From Puget Sound to Lake Samamish	30.10

The length of the reach from deep water of Puget Sound at Smiths Cove to a connection with the route via Shilshole Bay, at the head of Salmon Bay, is 2.59 miles.

No data concerning the rainfall in the immediate vicinity of the area of the drainage basins of the lakes are to be obtained. The nearest approach to such information is furnished by the continuous observations of rainfall since the beginning of 1878, made on Bainbridge Island, which lies at the west side of Puget Sound, about 12 miles due west of the middle of Lake Washington.

The following table gives the total amount of rainfall for each year at the locality named:

Year.	Rainfall.	Year.	Rainfall.
	<i>Inches.</i>		<i>Inches.</i>
1878.....	46.38	1885.....	43.68
1879.....	64.87	1886.....	34.92
1880.....	49.35	1887.....	40.09
1881.....	53.82	1888.....	39.97
1882.....	42.53	1889.....	27.88
1883.....	34.85	1890.....	30.26
1884.....	34.03		

The record for the year 1890, by months, is as follows:

Year.	Rainfall.	Year.	Rainfall.
	<i>Inches.</i>		<i>Inches.</i>
January.....	7.71	July.....	0.50
February.....	4.88	August.....	0.26
March.....	2.90	September.....	0.07
April.....	1.54	October.....	3.09
May.....	1.63	November.....	0.74
June.....	1.65	December.....	5.89

From the first table it will be seen that the average rainfall per annum for the thirteen years is 41.74 inches, and for the last five years, 34.62 inches.

The second table shows that the greatest precipitation occurs in December and January, when nearly 45 per cent of the whole annual rainfall is precipitated, and that the months of July, August, and September cover a dry period when the precipitation is less than 0.5 per cent of the total.

The data upon which to estimate the amount of the evaporation from the surface of the drainage basins and lakes are not obtainable, but from the fact that at all times, except when checked by a rise in the waters of Cedar and White rivers, there is an outflow from Lake Washington through Black River, it is evident that the supply from the drainage basins exceeds at all times the evaporation. The amount of this excess during the dry seasons it is impossible to determine upon any data at present available.

An examination of the tide tables for the Pacific coast, for 1891, shows that the average height of all the tides during the months of July, August, and September, referred to the plane of extreme low water, is 10.6 feet, and, as the low-water level of Lake Union, after the construction of the canal, will be 25 feet above the same plane, the average lift of the lock, either at Salmon Bay or Smiths Cove, will be 14.4 feet.

The lift of the lock at the Portage at the low-water stage in both lakes is 6.6 feet, and as the length and width of the prism of this lock are the same as those of the locks at Puget Sound, the relative amounts of water discharged in one lockage at each lock will be in proportion to the lift. The lock at Puget Sound will consequently require for the lockage of a vessel an average of nearly 2.2 the amount of water that is required for the same work at the Portage lock.

As the supply of water from the basin of Lake Union is, during the summer months, practically nothing, all the water required for the lockage at the outer lock during that period must be drawn from Lake Washington.

With a number of lockages at the Portage equal to that at the outlet, the volume of water supplied by the former lock will be less than one-half that required for the latter, and the deficiency must be supplied from Lake Washington by a channel other than that through the Portage lock. In the projects upon which the estimates have been based this is provided for for the dry season of the year by an independent culvert or channel.

During the portion of the year when the water supply to Lake Washington is such as to keep the water of that lake at a higher elevation this deficiency is provided for by the overflow of a waste weir at the Portage lock, any excess not required at Puget Sound being disposed of by a similar waste weir at the outer lock.

It is estimated that the average time required to fill or to supply the prism of either of the locks at Puget Sound will be ten minutes, and that ten minutes more will be consumed in moving a vessel in and out of the locks and in opening and shutting the gates, or that, for one complete lockage, either up or down, twenty minutes will be required.

The greatest number of vessels can be passed through either of the locks in a given time by passing them alternately up and down, and under such conditions one lockful of water only will be used in passing one vessel each way.

Under the assumption as to the time of operating the outer lock, one vessel can be passed each way through the lock in forty minutes, or thirty-six vessels each way in twenty-four hours, and thirty-six lockfuls of water will be required for the work.

The following are the areas of the respective drainage basins, and of the water surfaces which they contain:

	Area of drainage basin.	Area of water surface.
	<i>Sq. miles.</i>	<i>Sq. miles.</i>
Lake Samamish.....	102	8.0
Samamish River.....	109	0.3
Lake Washington.....	182	38.9
Lake Union.....	6	1.5
Total	399	48.7

The cubic capacity, between gates, of the prism of either of the locks at Puget Sound, with an average lift of 14.4 feet, is 302,400 cubic feet. As the inflow to Lake Washington during the dry season of the year is in excess of the evaporation from its surface, any draft upon the waters of that lake for lockage at Puget Sound will be in part supplied by the excess, which will be diverted from the outlet at Black River.

Assuming, however, that there is no excess to supply this draft in part, but that all of the lockage water required tends to the lowering of Lake Washington, it is found that the level of that lake will be reduced by continuous lockages during the three dry months to the extent of a little over nine-tenths of a foot. Any leakage of water at the outer lock in excess of that required for lockage and the water necessary to operate the hydraulic motors at the lock will increase the abatement. The amount of the leakage will depend upon the construction of the gates and valves, and by care in construction can be reduced to a small amount. The water required for power will be but a small fraction of the whole, and, until data for closer computation are afforded, may be ignored as immaterial in these approximations.

Assuming that the supply during the dry season will be furnished by the entire water area of Lakes Samamish and Washington and Samamish River, covering an area of 47.2 square miles as against 38.9 square miles of Lake Washington alone, the abatement due to the lockages during the three dry months will be three-fourths of a foot.

In the computations upon which the above statements are based, no account is taken of the small amount of rainfall during the three dry months, which if considered would decrease the computed abatement of the lakes.

Continuous and uninterrupted operation of one of the locks on Puget Sound during an entire year will admit of 13,140 double lockages. A rainfall of 4.35 inches during the entire year drained from the basins of Lakes Washington and Samamish and of Samamish River, having a combined area of 393 square miles, will supply all the water required for the total annual lockage.

The average current through the canal due to the water required for lockage will be less than three one-hundredths of a mile per hour.

Cedar River, entering Black River about a half a mile below the outlet of Lake Washington, is subject to annual floods, due chiefly to the melting of the snow at the headquarters of that river in the Cascade Mountains. At infrequent intervals in the past, this flood has reached large proportions, overflowing for a short time the land adjacent to the outlet. The ordinary annual floods, however, do not overflow the banks of the river.

During the height of these floods the direction of the current in Black River between Lake Washington and the mouth of Cedar River is reversed, and a large volume of water is then emptied into the lake, causing a very marked elevation of its level.

In former years the Duwamish River was more obstructed by bars and drift than at present, and the low bottom lands in that valley were covered with a dense growth of brush, which impeded the flow of water when those lands were submerged. The subsequent removal of obstructions in the river and the clearing of the low lands, permitting a much freer discharge toward Puget Sound, has so materially checked this reflux into the lake that the fluctuations of its level have been reduced from about 7 feet, reported as the maximum of former years, to less than 3 feet in recent years. It is probable that the last noted rise in the level of the water may be somewhat exceeded, as there has not been in recent years any extraordinary flood corresponding to that causing this former maximum rise.

The construction of the canal will open an outlet that will carry off to Puget Sound, through Lake Union and Salmon Bay, such a volume of water that will tend to further reduce the range of fluctuation in Lake Washington, without inducing a current that will interfere with the traffic on the canal or endanger its banks. The effect in that direction of the relatively small discharge through the existing small canal at the Portage has been manifest during the past few years.

It appears probable, therefore, that upon the recurrence of one of the greater floods after the construction of the canal the rise, by reason of the freer outlet offered to the water, will not be so excessive as to interfere with the navigation of the canal.

The fall in Black River is such as to admit of the enlargement of its channel by deepening the rock bottom so as to permit a larger outflow from Cedar River to the Duwamish River.

The following table shows the fall of the surface of the water in Black River, at the time of survey, over a distance of 8,300 feet, from the lake:

	Distance from Lake Washing- ton.	Interval.	Elevation above datum.	Fall.	Rate of fall; foot per hundred.
	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	
Lake Washington.....	0		33.1		
Head of Cedar Rapid.....	3,100	3,100	33.1	0.0	0.00
Mouth of Cedar Rapid.....	3,600	500	32.5	0.6	0.12
Foot of Cedar Rapid.....	4,500	900	30.8	1.7	0.19
Station 45.....	5,700	1,200	29.5	1.3	0.11
County road bridge.....	6,600	900	28.5	1.0	0.11
Railroad bridge.....	8,300	1,700	26.7	1.8	0.11

In the early consideration of the canal project the equalization of the levels of Lakes Washington and Union was considered: First, by lowering the level of Lake Washington to that of Lake Union; second, by raising the level of Lake Union to that of Lake Washington; and third, by bringing the levels of both lakes to one intermediate between the two.

All of these schemes dispense with the need of a lock at the Portage.

In those wherein the water of Lake Union is raised, the amount of excavation in the canal prism between that lake and the outer locks will be decreased, but the cost of the locks will be increased by reason of the greater lift required to be given to them.

The structures on the lake front are built to the present water level, and should the water materially be raised, extensive and costly changes would be required in such structures.

The raised lake level being carried through to the outer locks at Puget Sound, the lower parts of the town of Ballard and other lowland adjacent to Salmon Bay,

which, under the projects adopted in the estimates are submerged, would be flooded to a greater depth, and the area of submerged land largely increased; to such an extent, indeed, as to increase the measure of damages largely in excess of that of any advantages that might be derived from such a scheme.

The lowering of the level of Lake Washington to any considerable extent would check the outflow through Black River, or stop it altogether, and draw from Cedar River, especially during its flood, a larger part of its waters. In that case an outlet for the entire water of the drainage basins of the lakes, together with a part of the waters of Cedar Rapids largely in excess of that now emptying into the lake, would have to be provided for through the canal. This would materially interfere with the navigation of the canal, not only during the time of floods, but for some time thereafter, until the accumulated waters had passed off.

Under such a scheme, the amount of the excavation at the Portage would be very materially increased.

It is very doubtful whether it is practicable, to lower through a canal of the standard cross-section to be cut through at the Portage, the surface of the water in Lake Washington, containing an area of 38.9 square miles, to the level of Lake Union, and that of Lake Samamish and Samamish River, containing an area of 8.3 square miles attendant upon it.

The want of reliable data of the amount of rainfall and evaporation in this district; of the duration and rate of fall during the heaviest precipitation; of the retardation of such precipitation on its way to the lakes, and of the volume of discharge through the channels of Samamish and Black rivers, under various conditions of elevation of water surface in the lakes, precludes any estimate of the effect of the inflow and outflow upon the lakes.

The ratio of the area of the larger drainage basin, containing Lakes Samamish, Washington, and the Samamish River, to the entire water area of the basin is 8.33, and to the area of Lake Washington alone 10.10. These figures represent also the ratio of rise in the lakes to depth of rainfall, if such rainfall were entirely to find its way without impediment to the lake and the outflow were at the same time prevented. As, however, the rainwater is retarded on its way to the lake and the discharge is increased as the lake rises, a rise to the extent denoted by these figures will not occur. Only in the event of a heavy rainfall continuous for a long time can there be any material rise in the surface of the water of the lakes, and upon the abatement of such excessive rainfall the lowering of the water surface will speedily follow by reason of the uninterrupted outflow. Heavy rainfalls are of rare occurrence in this country. The rainfall during the rainy season is such as to make the supply to the lakes nearly uniform.

The excavations along the lines of railroads and streets, in the small canal through the Portage and in the ditch connecting Lake Union with Salmon Bay, show that the material of the upland in the vicinity of the proposed canal is largely composed of cement, gravel, and hardpan, with occasional beds of loose gravel and sand. Nowhere in the vicinity is rock exhibited except in the case of infrequent granite boulders. The nearest rock in place is a soft sandstone ledge which crosses Lake Washington in nearly east and west direction at the south end of Mercer Island and crops out in the Duwamish Valley a short distance above the mouth of the Duwamish River. This ledge is nowhere nearer than 6 miles to the proposed canal.

In the gap between Salmon Bay and Smiths Cove the railroad excavation which has been made has been through loose sand and gravel easily moved. It is probable that the deeper excavation required for the canal will be largely in harder material.

In Smiths Cove and Salmon Bay the bottom is of soft mud, with a substratum of hard material. The notes of pile-driving on the line of the Seattle and Montana Railroad show the depth of soft material in Smiths Cove, except near the high-water mark, to be from 30 to 50 feet, and throughout a greater part of their line across Salmon Bay to be from 20 to 30 feet deep, the hard material being below the limit of a canal excavation.

The area of deep soft mud in Salmon Bay does not probably extend beyond the wider parts of the bay. At and below the narrows the depth of soft mud is probably less, but as the depth of excavation for the canal is much less there than where the deeper mud occurs, the canal excavation will probably not to any extent encroach upon the harder substratum.

The bottom of Lake Union, wherever excavations will be required, is of stiff clay. In Union Bay the ooze forming the bottom is of considerable depth. The character of the substratum is not known, but it is probably of hard material similar to that exposed in the adjacent cut through the Portage.

Elsewhere along the line of the canal between Puget Sound and Lake Washington the material, with but little exception, will probably be found to be cement gravel and hardpan.

The material of the surface in the Samamish Valley is an alluvium, the depth of

which is unknown except at a few places in the upper part of the valley and at the abrupt bends near Lake Washington, where gravel and hard material are shown.

Lake Union has an area of $1\frac{1}{2}$ square miles. The length along its axis is $3\frac{1}{2}$ miles and the length of shore line following its principal indentations is $8\frac{1}{2}$ miles. The greatest depth of water is 60 feet, averaging 50 feet over a large extent, except at and near the head of the lake, at the Portage, where the water shoals. The shores are abrupt. This lake affords good anchorage ground.

Lake Washington has an area of 38.9 square miles, and a length, measured from north to south, of $18\frac{1}{2}$ miles. The length of the main shore line is 50 miles, and that of Mercer Island $11\frac{1}{2}$ miles. The greatest width is $4\frac{1}{2}$ miles at the head of Mercer Island, and the average width a little more than 2 miles. Excepting at the upper and lower ends of the lake, and in the few small bays along the shore, no shoals have been discovered. The shores, except at the shoals, are abrupt and fall rapidly to a depth exceeding 20 fathoms. It is reported on credible authority that in many places the depth exceeds 100 fathoms.

Lake Samamish has an area of 8 square miles and a length of 7 miles, with a length of shore line of 18 miles. The greatest width is $1\frac{1}{2}$ miles and the average a little over 1 mile. The shores are generally abrupt. A depth of from 50 to 60 feet is quite uniformly maintained. The shoals at the head and foot of the lake are of small extent.

Very respectfully, your obedient servant,

PHILIP G. EASTWICK.

Capt. THOMAS W. SYMONS,
Corps of Engineers, U. S. A.

APPENDIX—ESTIMATES OF COST.

A.—FROM PUGET SOUND TO HEAD OF SALMON BAY.

1.—Via Shilshole Bay.

Excavation:	Cubic yards.	
Shilshole Bay.....	302,000	
Pool below lock.....	161,000	
Lock pit.....	84,000	
Salmon Bay.....	324,000	
Total.....	871,000 at 50 cents.....	\$435,500.00
Masonry lock at Salmon Bay:		
Inclosure for lock pit:		
Piles, 140, 28 feet long, 3,920 linear feet, at 8 cents.....		\$313.60
Driving piles, 140, at \$3.....		420.00
Lumber:		
	Feet, B. M.	
Wales, 3,400 linear feet, 8 by 8 inches.....	18,000	
Plank, 15,000 square feet, 3 inches.....	45,000	
Total.....	63,000 at \$10.....	630.00
Iron and spikes:		
	Pounds.	
Drift bolts, 420, $\frac{3}{4}$ by 20 inches.....	700	
Cut spikes, 6 inches.....	1,000	
Total.....	1,700 at 4 cents.....	68.00
Erecting, 63,000 feet, B. M., at \$10.....		630.00
Embankment, spreading and packing soil from excavation, 16,000 cubic yards, at 10 cents.....		1,600.00
Masonry:		
	Cubic yards.	
Main lock walls.....	32,000	
Guard-gate recess walls.....	2,000	
Upper lock-gate recess walls.....	1,300	
Lift wall.....	220	
Invert under main prism.....	3,700	
Invert under head bay.....	360	
Invert under tail bay.....	250	
Upper miter-sill wall.....	60	
Double lower miter-sill wall.....	140	
Stepdown.....	25	
Counterparts.....	570	
Culverts.....	1,600	
Total.....	42,225	
Classified as follows:		
Granite coping, quoins, sills, etc., 300 cubic yards, at \$75....	22,500.00	
Wall and culvert facing, 1,700 cubic yards, at \$15.....	25,500.00	
Concrete, 40,225 cubic yards, at \$8.50.....	341,912.50	
		389,912.50

Steel lock gates:		
Guard gate, 26 tons, at \$200.....	\$5,200.00	
Lower lock gate, 34 tons, at \$200.....	6,800.00	
Upper lock gate, 16 tons, at \$200.....	3,200.00	
Gate bearings, 6 tons, at \$500.....	3,000.00	
Gate anchorages, 6 tons, at \$500.....	3,000.00	
Gatepost anchor straps, 6 tons, at \$500.....	3,000.00	
	<hr/>	\$24,200.00
Power house (including foundations and turbine wells).....		10,000.00
Machinery for operating locks and erecting same:		
Turbines, 56 inches diameter, 2, at \$1,500.....	3,000.00	
Hydraulic gate engines, 6, at \$500.....	3,000.00	
Hydraulic sluice gates and engines, 4, at \$1,000.....	4,000.00	
Hydraulic capstans and engines, 6, at \$1,000.....	6,000.00	
Hydraulic accumulator pumps, 2, at \$1,500.....	3,000.00	
Accumulator reservoir.....	2,000.00	
Snubbing posts, 6, at \$200.....	1,200.00	
Pipes and valves to connect engines with accumulator reservoir.....	3,000.00	
Supply and delivery pipes for turbines.....	5,000.00	
	<hr/>	30,200.00
Dwelling house for gate-tenders.....	5,000.00	
Electric-light plant for lighting locks.....	4,000.00	
Removal of bulkheads.....	2,000.00	
	<hr/>	\$468,974.10
Dam and embankment at Salmon Bay:		
Excavation for foundation, 3,000 cubic yards, at 50 cents.....	1,500.00	
Lumber, 270,000 feet B. M., at \$10.....	2,700.00	
Iron and spikes, 26,000 pounds, at 4 cents.....	1,040.00	
Erecting of timber structure, 270,000 feet B. M., at \$10.....	2,700.00	
Earth and puddle filling of dam:		
Puddle, 1,600 cubic yards, at 75 cents.....	1,200.00	
Earth (spoil from excavation), spreading and ramming 3,200 cubic yards, at 20 cents.....	640.00	
	<hr/>	1,840.00
Earth embankment: To connect dam with lock walls and shore (spoil from excavation), spreading and ramming 40,000 cubic yards, at 15c.....	6,000.00	
Stone revetment: To protect outer slope of dam, 3,200 cubic yards, at \$2.....	6,400.00	
	<hr/>	22,180.00
	<hr/>	926,654.10
Engineering and contingencies, 10 per cent.....		92,665.41
Total.....		<hr/> 1,019,319.51

2. Via Smiths Cove.

Excavation:		Cubic yards.	
Smiths Cove.....	223,000		
Pool below lock.....	178,000		
Lock pit.....	84,000		
Boulevard cut.....	963,000		
Salmon Bay.....	249,000		
Total.....	1,697,000, at 50 cents.....		\$848,500.00
Masonry lock at Smiths Cove: Estimated to cost the same as that at Salmon Bay.....			468,974.10
Dam and embankment at the narrows in Salmon Bay.....			25,000.00
Wagon-road bridge, pier, and abutments, including electric motor to operate same.....			8,000.00
Land damages and right of way:			
21 acres at \$1,000.....	\$21,000.00		
17 acres at \$3,000.....	51,000.00		
	<hr/>		72,000.00
	<hr/>		1,422,474.10
Engineering and contingencies, 10 per cent.....			142,247.41
Total.....			<hr/> 1,564,721.51

B.—FROM HEAD OF SALMON BAY TO LAKE UNION.

Excavation:		Cubic yards.	
Fremont Cut.....	701,000		
Shoal, foot of Lake Union.....	13,000		
Total.....	714,000, at 50 cents.....		\$357,000
Wagon-road bridge, piers, and abutments, including electric motors to operate same:			
At Ross, 1 bridge.....		\$8,000	
At Fremont, 1 bridge.....		8,000	
Electric wire line to connect motors at bridges with dynamo at lock, 4 miles, at \$500.....		2,000	
	<hr/>		18,000

Land damages and right of way, 20 acres at \$3,000	\$60,000
Removal of sawmill, dwellings, and stores at Fremont	25,000
	<hr/>
Engineering and contingencies, 10 per cent	460,000
	<hr/>
Total	506,000

C.—FROM LAKE UNION TO LAKE WASHINGTON.

Excavation:	Cubic yards.	
Shoal, head of Lake Union	135,000	
Lock pit	67,000	
Portage cut	537,000	
Shoal, Union Bay	385,000	
	<hr/>	
Total	1,124,000, at 50 cents	\$562,000

Masonry lock at Portage:	
Inclosure for lock pit, embankment (spoil from excavation), spreading, and packing, 14,000 cubic yards, at 10 cents	\$1,400

Masonry:	Cubic yards.	
Guard-gate recess walls	1,400	
Main lock walls	24,000	
Upper lock-gate recess walls	1,400	
Lift wall	115	
Invert under main prism	3,700	
Invert under head bay	360	
Invert under tail bay	250	
Upper miter-sill wall	60	
Double lower miter-sill wall	140	
Stepdown	20	
Counterparts	340	
Culverts	1,600	
	<hr/>	
Total	33,385	

Classified as follows:

Granite coping, quoins, sills, etc., 300 cubic yards, at \$75	\$22,500.00	
Wall and culvert facing, 1,500 cubic yards, at \$15	22,500.00	
Concrete, 31,585 cubic yards, at \$8.50	268,472.50	
	<hr/>	313,472.50

Steel lock gates:

Guard gate, 16 tons, at \$200	3,200.00	
Lower lock gate, 13 tons, at \$200	2,600.00	
Upper lock gate, 18 tons, at \$200	3,600.00	
Gate bearings, 6 tons, at \$500	3,000.00	
Gate anchorages, 6 tons, at \$500	3,000.00	
Gatepost anchor straps, 6 tons, at \$500	3,000.00	
	<hr/>	18,400.00

Power house, including foundations and turbine wells

10,000.00

Machinery for operating locks and erecting same:

Turbines, 56 inches diameter, 2, at \$1,500	3,000.00	
Hydraulic gate engines, 6, at \$500	3,000.00	
Hydraulic sluice gates and engines, 4, at \$1,000	4,000.00	
Hydraulic capstans and engines, 6, at \$1,000	6,000.00	
Hydraulic accumulator pumps, 2, at \$1,500	3,000.00	
Accumulating reservoir	2,000.00	
Snubbing posts, 6, at \$200	1,200.00	
Pipes and valves to connect engines with accumulator reservoir	3,000.00	
Supply and delivery pipes for turbines	5,000.00	
	<hr/>	30,200.00

Dwelling house for gate-tenders

5,000.00

Electric-light plant for lighting locks

4,000.00

Removal of bulkheads

2,000.00

384,472.50

Dam and embankment at Portage:

Excavation for foundation, 3,000 cubic yards, at 50 cents	1,500.00	
Lumber, 170,000 feet B. M., at \$10	1,700.00	
Iron and spikes, 15,000 pounds, at 4 cents	600.00	
Erecting timber structure, 170,000 feet, B. M., at \$10	1,700.00	
Earth and puddle filling of dam:		
Puddle, 800 cubic yards, at 75c	600.00	
Earth (spoil from excavation) spreading and ramming 1,600 cubic yards at 20c	320.00	
	<hr/>	920.00

Earth embankment to connect dam with lock walls and shore (spoil from excavation) spreading and ramming 10,000 cubic yards at 15c

1,500.00

Stone revetment to protect outer slope of dam, 2,000 cubic yards at \$2

4,000.00

11,920.00

Sluice gate at Portage to supply water for outer lock during the dry season		\$5,000.00
Wagon-road bridge, piers, and abutments, including electric motors to operate same:		
At Latona, one bridge	\$8,000.00	
At The Portage, one bridge	12,500.00	
Electric-wire line to connect motors at bridges with dynamo at lock, $1\frac{1}{2}$ miles, at \$500	750.00	
		21,250.00
Land damages and right of way, 12 acres, at \$500		6,000.00
Extinguishment of existing canal rights		30,000.00
		1,020,642.50
Engineering and contingencies, 10 per cent.		102,064.25
Total		1,122,706.75

D.—FROM LAKE WASHINGTON TO LAKE SAMAMISH.

Excavation of canal prism:	Cubic yards.	
Shoal head of Lake Washington	455,000	
Lock pit	50,000	
Samamish Valley cut	6,770,000	
Total	7,275,000 at 50 cents ..	\$3,637,500.00
Excavation of drainage ditches at sides of canal, 504,000 cubic yards at 50 cents		252,000.00
Masonry lock at Lake Washington, complete		410,000.00
Dam and embankment at Lake Washington		15,000.00
Wagon-road bridge, piers, abutments and approaches, 9 bridges at \$8,000		72,000.00
Railroad bridges, piers and abutments, 4 bridges at \$10,000		40,000.00
Changes and readjustment of Seattle, Lake Shore and Eastern Railway		10,000.00
Land damages and right of way, 428 acres at \$100		42,800.00
		4,479,300.00
Engineering and contingencies, 10 per cent.		447,930.00
Total		4,927,230.00

Change of railway locations at and near Salmon Bay.

ESTIMATE OF COST.

Excavation 32,000 cubic yards, at 30 cents		\$9,600.00
Embankments (spoil from excavation) spreading 104,000 cubic yards, at 15 cents		15,600.00
Double-track trestle, 1,300 lineal feet, at \$9		11,700.00
Single-track trestle, 1,100 lineal feet, at \$6		6,600.00
Drawbridge combined rail and wagon roads including piers, abutments, and electric motor to operate same		15,000.00
Raising and readjusting old track two-thirds of a mile, at \$400		266.67
Removing abandoned track $3\frac{1}{2}$ miles, at \$400		1,250.00
New material for excess of new location over old location, new rails, 60 pounds per yard, 19 tons, at \$40	\$760.00	
Fish-plates, 2,200 pounds, at 4 cents	88.00	
Fish-plate bolts, 300 pounds, at 5 cents	15.00	
Cross-ties, 9,000, at 25 cents	2,250.00	
Railroad spikes, 18,000 pounds, at 4 cents	720.00	
		3,833.00
Laying new track, $3\frac{1}{2}$ miles at \$800		2,866.67
Ballasting, 8,200 cubic yards, at 75 cents		6,150.00
Right of way, 6 acres, at \$1,500		9,000.00
		81,666.34
Engineering and contingencies, 10 per cent.		8,166.63
Total		89,832.97

COMMUNICATION OF MR. WESLEY WILSON, MANAGER SEATTLE COAL AND IRON COMPANY.

SEATTLE, WASH., *March 24, 1891.*

GENTLEMEN: Having been advised of your being in this city for the purpose of looking over the ground of the proposed route of said canal, and obtaining such information as to the necessity of, and needs to, commerce and the probable advantage to be derived therefrom, I would, on behalf of the Seattle Coal and Iron Company, beg to submit the following for your information:

Our mines are located at Gilman, King County, Wash., about 3 miles distant from the head of Samamish Lake.

Our capacity to produce coal eighteen months ago, was 150 tons per day. Our capacity to-day is 600 tons per day, a large portion of which, say 350 to 400 tons per day, we find a market for in San Francisco, Cal., and other towns and cities on the Pacific Coast.

South of us we have also sent some of our coal to Honolulu. We expect within the next year or two to be able to increase our output to 2,000 tons or more per day, most of which will require to be shipped by water to points of consumption.

We find ourselves very much handicapped by the enormous expenses of maintaining bunkers for the loading of coal into sea-going vessels in the salt water of Puget Sound, by reason of the ravages of the teredo on the piles required to support the bunkers necessary to transfer said coal from the railroad cars to the vessels. So bad are they that we have had piles entirely destroyed that were not in use over four months, and we have found the average life of an unprotected pile to be not over nine months and the cost of such piles to be about \$5 each when in place.

The cost of bunkers erected on such a foundation as mentioned is very expensive indeed, and when the foundation gives way from causes stated it is almost an impossibility to replace the same, on account of there being no way to get new piles driven without first virtually destroying the upper structure.

Our present facilities we regard as but temporary and contain no storage compartments, simply enabling us to dump coal from cars to ship one car at a time, which process is slow and expensive and causes much detention to vessels, thereby adding to the cost of transportation on account of such detention. We have expended about \$65,000 toward the erection of permanent facilities for holding coal in bunkers, and it will cost us at least \$35,000 more to complete same. These when completed will enable us to give quick dispatch to vessels, which will enable us to secure lower rates for transportation, from which all our customers will derive substantial benefit in the decreased cost of fuel. Could we get vessels into fresh water and erect extensive bunkers there, which we would do, the cost of their maintenance would be merely nominal, which would enable us to still further reduce the cost of fuel to manufacturers and other consumers, which would assist largely in building up manufacturing industries on the Pacific Coast as against foreign competition in manufactured products, and by reducing the cost of fuel from our mines to the Pacific Coast would shut out very much of the foreign coals that are being imported to San Francisco and other points on the coast, thereby enriching our own citizens by keeping the money paid for same, instead of impoverishing them by having to send the money to foreign countries to pay for same.

In my judgment the benefits to be derived from being able to get the largest sea-going vessels into fresh water through the proposed canal, would in a very few years be simply almost incalculable.

You will please bear in mind that I have spoken of one industry (coal) only, which is only one of many. I firmly believe that all the foreign shipments of coal going from the Pacific Northwest would go via this projected waterway in the near future.

For information as to the tonnage of other large producing companies that would be immediately tributary to this route, I would respectfully refer you to Jno. L. Howard, esq., manager of the Oregon Improvement Company, and P. B. Cornwall, esq., president Black Diamond Coal Mining Company, both of San Francisco, and to J. L. Coleman, esq., secretary of the Cedar River Coal Company, of this city: All of which has been hastily written and respectfully submitted in the hope that it may aid you in forming your conclusions as to the pressing need of the early completion of this almost indispensable outlet for traffic.

I beg to remain, gentlemen, with kind regards, your most obedient
WESLEY WILSON, *Manager.*

Col. G. H. MENDELL,
Maj. THOMAS H. HANDBURY,
Capt. THOMAS W. SYMONS,

*Chairmen and members of the Board of U. S. Engineers in the matter of
ship canal from Puget Sound to Lake Samamish, King County, Wash.*

LETTER OF MR. J. FURTH, PRESIDENT CHAMBER OF COMMERCE, SEATTLE, WASH.

CHAMBER OF COMMERCE,
Seattle, Wash., June 23, 1891.

DEAR SIR: I have the honor to submit herewith, for your perusal, statement which has been prepared by a special committee of this association bearing upon the necessity and benefits to be derived from a ship canal connecting the waters of

Puget Sound with Lake Washington. After reading, we would be pleased to have you forward it, with other matter which you are having prepared bearing upon the subject, to the War Department.

This statement has been compiled as suggested by you when here.

Yours respectfully,

J. FURTH, *President.*

Col. G. H. MENDELL.

STATEMENT OF COMMITTEE OF CHAMBER OF COMMERCE, SEATTLE, WASHINGTON.

The survey authorized by Congress of the proposed ship canal to connect Lake Washington with Puget Sound at Seattle having been completed, the attention of the honorable Secretary of War is respectfully invited to the following, presenting some of the reasons why this canal should be promptly constructed: The city of Seattle is situated almost in the center of the Puget Sound region and has a frontage on salt water of more than 6 miles. Lake Washington lies abreast of the city to the eastward parallel with the Sound, and stretches north and south 25 miles. Deeply embayed by a cordon of mountains, its surface is always smooth and safe; its shores are bold but not rocky; its waters of ample depth, soundings showing in places 100 fathoms. Its width near its central section is 4 miles and the average nearly 3, affording ample room for handling vessels of the largest size. The absence of tides and currents renders its waters always tranquil and of even stage, and preserves its banks without washing. Its outlet by an easy channel enters the sound almost within the present city limits.

Bordered with fertile lands, backed with inexhaustible forests of finest timber, and immense fields of coal, iron, and the precious minerals, the situation of this lake has not failed to attract the attention of every one versed in the ways of business or commerce who has visited the region.

Another such body of fresh water lying within 2 miles of a noble ocean roadstead with which it may easily be joined, capable of being converted into anchorage ground for the fleets of the world, does not exist elsewhere; it would seem to have been provided by nature as a complement to our harbor system which it will make perfect in its every feature.

Puget Sound having been for many years marked as the seat of coming great commercial expansion has become within the last decade the focus of enterprise looking to the realization of its future—four great transcontinental railway lines for the termini of their systems. Already two of them are establishing ocean steamship lines to Asia and the oriental islands.

From all parts of the world come fleets of vessels to this inland sea to compete for the cargoes which lie close at hand or arrive as freights of railways spanning the continent. The tide of progress in trade and commerce is so rapid as to run ahead of the facilities provided, and such is likely to be the case for years to come. The eyes of the industrial world are set this way.

A cursory glance at the resources of the State shows good reasons for faith in its future.

The wheat yield of 1890 was about 20,000,000 bushels; that for the current year is estimated at over 25,000,000 bushels. The capacity of the natural wheat fields of the State is conservatively placed at 200,000,000 bushels per year. Oats, barley, hay, fruits of all kinds, and every farm crop reward the husbandman with prodigious returns.

The lumber cut of the State for 1890 was 1,222,830,042 feet, an increase of 538,647,042 feet over the preceding year; nearly 100 per cent. This does not include the lumber cut into laths, pickets, etc., estimated at 174,186,800 feet.

The coal output of the State for 1890 was 1,349,773 tons, an increase of 438,246 tons, or about 50 per cent for the year.

The coal measures are practically limitless in extent, and the business of shipping coal is in its infancy. The amount of coal mined hereafter will be limited only by the demand for it.

Iron ores of the best quality, fit for steel making, cover an immense field. Works for its manufacture are in course of construction at several points.

The precious metals are distributed over a wide area and promise enormous development of wealth. Gold, silver, lead, copper, tin, asbestos, graphite, limestone, marble, granite, and sandstone are to be added to iron and coal. All these combined furnish an opulence of mineral resources rarely encountered in a single field.

A State possessing unrivaled agricultural advantages, and having superadded to these such incomparable wealth in timber and minerals, can not fail to develop manufacturing interests on a gigantic scale. Such development is already entered upon.

With the completion of the railroads now speeding to their terminals at this point, the State will have an enjoyment of transportation lines greater and more perfect

than any one State has hitherto equipped. She will be prepared to handle with utmost dispatch the traffic which throngs at her gates.

Great as the outlook for domestic trade may appear, it does not exceed the just scope for foreign commerce.

The trade of China alone is conservatively estimated at \$150,000,000 annually. That country has but just begun to make use of American products in large amounts. Every year she adds to her demands for timber, flour, and manufactured goods. But the special field for expansion of trade is in manufactures of iron and steel.

A country without railways, her manifest destiny is to develop on a scale demanding enormous consumption of iron and steel, these modern means of improving civilization. Asiatic Russia has already entered upon this work in her possessions north of China.

Australia is opening wide doors to American trade, and cargoes to her ports multiply yearly in astonishing ratio.

Japan and the coast countries are adding steadily to the volume of commercial business with our people. In South American countries, several of them possessing immense timberless savannas, the lumber of Puget Sound finds a profitable and growing market. This trade is apparently only in its incipency, and is being augmented constantly.

Machinery, domestic utensils, manufactures of iron and wood, every product of our workshops, whether made on the Pacific or coming by rail from eastern centers, are now to be added to the list of articles for trade with the South American States, a people rich in resources but possessing meager manufactures. Return cargoes of sugars, coffee, spices, precious woods, dyestuffs, gums, tropical fruits, and nitrates will seek these waters for their distribution by the railways to inland points.

The Nicaragua Canal, a necessity of the times and certain now of speedy construction, will open the door to a vast tide of commerce from the Atlantic seaboard, from ports both of the United States and South America. It will reduce by one-half the distance to European ports and bring a mighty current of traffic from that country.

Thus from Asia, the greater island of the southern ocean, the rich East India ports, the immense stretch of the Atlantic seaboard, the fruitful lands of western Europe, a rising volume of commercial business is sweeping this way and must be received and cared for in Puget Sound or else surrendered to our active and determined competitors to the north of us.

It is not too much to assert that a commercial expansion equal to that now existing at the port of New York is impending for these waters. A far greater shore line than that port has will be essential for the proper accommodation of the docks and wharves required here for the reason that nearly the entire shipping of the Pacific coast must find harbor facilities at a few ports embracing Puget Sound, San Francisco, and the mouth of the Columbia River, whereas many good harbors exist on the Atlantic seaboard within easy radius of New York.

Australia and all of Oceanica lie nearer to Puget Sound than to England on the Pacific side; the Malay peninsula makes the halfway point. Japan and all northern Asia are thousands of miles nearer to us than to London. Our commerce is now within less than three weeks of the coast of China. Statistics show that New York by way of Puget Sound is 1,400 miles nearer to Canton than is Liverpool, and about 4,000 miles nearer Shanghai.

Puget Sound has also the advantage in distance to Asiatic points over San Francisco. The following table of distances, culled from Prof. Ruffer's interesting report upon the State of Washington, presents significant data upon the nearness of Puget Sound to points of commercial vantage ground:

Seattle to—	Miles.
Mouth of Amoor River	3,900
Vladivostock	4,700
Shanghai	5,750
Canton	6,500
Singapore	8,100
Southwest point of Australia.....	9,550
San Francisco to—	
Vladivostock	5,200
Shanghai	6,100
Canton	6,800
Singapore	8,400
Southwest point of Australia.....	9,500
Calcutta.....	10,200
Liverpool to—	
Mouth of Amoor River.....	13,550
Vladivostock	12,700
Shanghai	11,750

	Miles.
Liverpool to—	
Canton	10, 900
Southwest point of Australia.....	10, 750
Singapore.....	9, 300
Calcutta.....	8, 700
New York to—	
Canton via Puget Sound	9, 500
Shanghai via Puget Sound.....	8, 000

It is well known that the carrying trade of the world is being transferred by rapid stages from wooden bottoms to hulls of iron and steel. So fast is the transfer being made that wooden-ship yards are constantly going out of commission. Vessels of war are no longer thought of as made of wood. Iron and steel rule the shipping of all seas.

It is also well known that iron and steel bottoms are subjected in salt water to marine growths which adhere to them and greatly impair the efficiency of the vessels. The speed of an iron ship is often reduced one-half by the presence of grass and barnacles adhering to the bottom, and the cost of maintaining such vessels is greatly enhanced by the necessity of frequent docking to remove these accretions. Fresh water destroys marine growths and prevents their formation. Barnacles and grass, which cover a vessel's bottom in salt water to the weight of many tons, are killed by a few days in fresh water and will drop off, or may be removed easily with scrapers. So advantageous to iron shipping is an accessible body of fresh water that masters of vessels regard it as of importance next to cheap fuel at ports of arrival from sea voyages. One of the material advantages named in favor of building the Nicaragua Canal is the fact that a fresh-water lake lies midway of the canal route, and that ships will pass through it in their progress from ocean to ocean, and may avail themselves of its waters for freeing their bottoms from marine accretions. Puget Sound possesses cheap fuel for coaling vessels; it has abundant cargoes; a canal to Lake Washington will add immensely to its present advantages.

The most ample and perfect facilities are of paramount importance to the great transcontinental railway lines which converge here. If these railways are important and necessary from a military point of view, if they tend to bind together and unify the distant sections of the Republic, and hence possess national importance beyond their value as transportation lines, then certainly they should have complete terminals to enable them the more efficiently to aid in the work of developing and building up the material resources of the country. In this connection the fact is not to be lost sight of that our neighbor, the Dominion of Canada, spares no expense and loses no opportunity to make perfect her transcontinental railway facilities, and that she is preparing to contest with us most strenuously for the ocean carrying trade.

With a ship canal joining the waters of Lake Washington with Puget Sound our advantages for shipping would be ideal in character and superior to those of all other ports on the Pacific coast. Indeed this unique advantage would make Seattle preëminent in facilities for shipping amongst the ports of the world. A vessel could come to her dock in fresh water undisturbed by tidal flow, and while discharging cargo her bottom would be cleared of its burden of barnacles and grass without the delay and expense of docking. She would thus save two or three days' time as well as considerable expense. The demurrage alone thus avoided would aggregate for the tonnage entering the port a large sum each year.

But a desideratum of the most practical importance is the increase of shore line available for wharves and docks which this improvement involves. Lake Washington would add more than 50 miles to the dock front of Seattle, increasing her harbor capacity tenfold and giving here transcendent advantages in this regard.

The maintenance of wharves and docks in the salt water of the sound is now very expensive by reason of the ravages of the teredo, which often destroys piling within a single year after driving, so that the wharf goes down with loss of its entire stores, and sometimes with loss of life. In the fresh water of the lake piling will last practically without limit. The saving in the cost of maintaining docks and wharves alone would far more than repay the cost of constructing the canal.

Manufactures already seek Lake Washington; its fresh water for making steam, its nearness to the coal and iron mines, its cheap wharf facilities, and the ample room which it affords, counterbalancing the expense of rehandling the manufactured product when shipped foreign. Three railway lines, the Northern Pacific, the Great Northern, and the Seattle, Lake Shore and Eastern, have already established themselves on the lake and its outlet, recognizing its great commercial importance. The Northern Pacific Company has built a road along the whole eastern front of the lake. But notwithstanding the railway facilities, many industrial enterprises are precluded from locating here while the canal is not built, such as flouring mills,

grain elevators and warehouses, lumber mills, etc., whose products are shipped largely by vessel.

Every foot of the shore line of this lake would come into practical use for the accommodation of shipping and manufactures, were the canal built.

The timber of the coast and bordering upon the rivers near the coast has been nearly used up, so that the vast forests of the interior must now be resorted to for supplying the demand. Twenty million acres of these forests must be reached by rail. An enormous timber product will come to Lake Washington and be manufactured and shipped hence, when the proposed connection with the Sound is completed.

Wheat warehouses, elevators, and flouring mills, for handling and manufacturing the immense yield of grain which the wheat fields of eastern Washington produce in amounts largely increasing every year, await establishment here only until such time as the canal to the Sound is completed.

A comprehensive plant for the reduction of iron ores and the manufacture of steel is in course of construction at Kirkland, a manufacturing suburb of Seattle, on the east side of Lake Washington. This blast furnace will use the magnetic ore from the Denny iron mines, situated about 30 miles east of the lake. The ore (referred to in another place) compares favorably with the magnetic ores of Lake Superior, hitherto ranking as the best upon the continent. The railway which will bring in this ore will also bring superior coking coal from the Niblock coal mine, located only 20 miles east of Kirkland. This will be coked and used in the manufactories on the banks of the lake.

Smelting works for ores of the precious metals will also be established on the lake where coke will be convenient, the ores coming by rail on a down grade from the mines.

A great city placed at the focal point where the commercial tides of two continents converge will beget an infinite number and variety of important industries, while the wondrous progress of the age will in its swift march bring forth others not yet known to the inventor. The unmistakable signs of the time point to this as a great manufacturing and industrial center.

Congress is recreating the Navy of the United States, but as yet the work is hardly begun. The position of Puget Sound demands here a large fleet. A Government dry dock has been provided for already, to be followed probably with a fully equipped navy-yard.

A ship canal into Lake Washington would afford in these waters the most complete advantages for naval vessels of any in the United States. If there was a military reason for endowing the Pacific railways and making them national highways, there is a still stronger military reason for Government owning the proposed canal and removing it from the control of private persons or corporations, since this improvement would be the link connecting the military railway with a terminal position of great strength available for naval protection.

While commercial development would be greatly stimulated and the establishment of manufactures accelerated by reason of the proposed improvement, the expense of wharfage and dockage, the handling of cargoes, the lading of vessels and storing of freights, in fact the cost of all the various changes on shipping at the port, of whatever nature, would be materially lessened, as a result of the ample extent of water front and ship anchorage provided for the city of Seattle.

Not only for economic reasons, but for reasons of prudence and sound national policy, the Government should provide, control, and manage this enterprise, shown to be of prime national importance.

The cost of the work is but a bagatelle in view of the interests to be subserved, and the results certain of attainment.

THOMAS BURKE,
J. FURTH,
E. W. CLARKE,
C. M. SHEAFE,

Chamber of Commerce Committee.

COMMUNICATION OF MR. J. W. DODGE, SECRETARY CHAMBER OF COMMERCE, SEATTLE, WASHINGTON.

THE CHAMBER OF COMMERCE,
Seattle, Washington, June 30, 1891.

DEAR SIR: Since reading and forwarding to you statement compiled by special committee of the chamber bearing upon the Lake Washington canal project, it has occurred to me that some points of importance in determining the size of the canal, character of locks, etc., were not mentioned. I therefore take the liberty of calling your attention to a few points that present themselves to my mind. The first, is the probable amount of coal tonnage. At the present time, there are five mines tributary to Lake Washington in operation; one developed, but not yet producing, and

three in process of development. The names and daily capacity of the mines in operation, also the prospective capacity of each in the event of proper shipping facilities being afforded, are below given:

Name.	Present daily capacity.	Prospective daily capacity.
Gilman.....	600	2,000
Newcastle.....	1,000	2,000
Cedar River.....	200	500
Black Diamond.....	1,000	2,000
Franklin.....	500	1,000
Total.....	3,300	7,500

The next feature that occurs is the amount of lumber that would be shipped from Lake Washington were facilities afforded.

There has been during the past year cut and floated on Lake Washington, for the use of mills located on Lakes Union and Washington, about 9,000,000 feet of logs, and there is being handled at the present time about 300,000 per working day. This would be but a small portion, comparatively speaking, of the amount that would be handled were there direct shipping facilities from the lake. It is estimated that there are 16,000,000,000 feet of timber now standing in King County. Over one-half of this, and an equal amount in Snohomish County, is directly tributary to Lake Washington. Western Washington is destined to be a heavy producer of metals, both base and precious, and while it would be impossible to estimate the extent of shipments of the various classes it is but proper that attention should be called to the fact that extensive iron and steel works are now under construction; that a company has recently been formed for the purpose of smelting and refining precious metals, the extent and value of which are each day becoming more apparent.

The size and character of vessels which would frequent these waters in case the canal was constructed would also be a matter of importance to you in determining the size of locks and depth and width of basins. From the best information I am able to gather from vessel owners, it is apparent that there is a decided tendency to increase the tonnage capacity. Bearing in mind that the freight would consist chiefly of coal, coke, grain, lumber, furniture, machinery, iron products and other metals, the canal and locks should be capable of handling vessels of large capacity. Vessel owners here are of the opinion that the prevailing type will be of about the following average: 2,000 tons register, 350 feet in length, drawing 26½ feet water, 43 feet beam. Grain merchants seem to think that vessels similar to the *John R. Kelly*, which has net tonnage of 254, and length of 256.9 feet, breadth of 45 feet and depth 27.8 feet, will represent the style of grain carrier. The fact that the new steel barges, which are now in use to a limited extent on the Great Lakes, will also soon be plying these waters, should also be borne in mind. No estimate has been made of the probable amount of grain shipments, for the reason that our experience in this line has been for so limited a period (the first elevator shipments from this port being made in August, last year) that we can not with any degree of accuracy estimate it. The elevator, which was completed and commenced business last August, has handled under adverse circumstances about 1,000,000 bushels during the past ten months, all received from one line of road. With the completion of the great Northern and Union Pacific and the extension of other roads now in prospect, which will pass through large areas of grain-producing land, the amount of tonnage that can and will be handled under favorable conditions is beyond estimate. Bulletins issued by the Agricultural Department show that Washington outranks all States of the Union in the yield per acre of wheat, oats, barley, and potatoes. The yield of wheat in the State for the past year has been estimated at 20,000,000 bushels. Bearing in mind the immense area of as yet uncultivated lands adapted to the production of this and kindred grains, the future of that branch of business can not be estimated.

Yours respectfully,

J. W. DODGE, *Secretary.*

Col. G. H. MENDELL.

REASONS WHY CONGRESS SHOULD CONSTRUCT A SHIP CANAL INTO LAKES UNION AND WASHINGTON, IN AID OF COMMERCE.

The advantages of a fresh-water harbor are so well known and have been so voluminously set forth by engineer officers of the Government at various times heretofore, that it is hardly necessary to give any further reasons why a fresh-water harbor should be preferred to salt water. If, therefore, it can be shown that the commerce

of the State of Washington is so extensive that the saving in wear and tear of wharves, in deterioration of ships and vessels of all kinds, can be a material measure reduced, or reduced to such an extent that the saving will be a great benefit not only to ship owners, but in lessening the cost of transportation and terminal charges upon the handling of the grain and other products of the country, it is hardly necessary to say that Congress will be justified in making a sufficient appropriation to build a canal into these waters. This would certainly be so if such saving would be sufficient to pay a large interest upon the cost of building such a canal. It is a well-known fact that the ravages of the teredo in the waters of Puget Sound, and, in fact, in all the waters of the Pacific Ocean, are so great as to be a tremendous tax upon commerce. All the wharves in these waters require renewal on an average of less than two years. It is safe to say that all necessary wharves could be constructed in Lake Washington for the accommodation of all the heavy commerce of the State at one-fourth the first cost that would be required to construct such wharves in the waters of Puget Sound or the Pacific Ocean; that such wharves and warehouses would last at least ten times as long, and that their maintenance in the fresh waters of the lake would be an infinitesimal sum, a small fraction of what they are in the salt water.

Again, the cost of handling ships at the wharves and the transfer of freight from rail to ship would be but a small fraction of what it is upon the sound. This would be so because of the level in the lakes being the same at all times. After the ships were once in the lake they would be absolutely safe from winds and storms.

If a canal were constructed into Lake Washington it is pretty safe to say that nearly all of the wheat and coal shipments of the State would be from the lake. This would be so because of the very small cost of handling such products for the reasons above stated, and because it is easier for all of the railroads to reach the waters of the lake than it is to reach the waters of the Sound.

As a matter of fact all of the existing railroads in the State have, either by themselves or by rail, direct contact with the shores of the lake. The amount of coal shipped now from the Sound, mainly from King and Pierce counties, is in the neighborhood of 2,000,000 tons per annum. These shipments in the near future are not unlikely to be more than doubled. The wheat product of the State for the year 1890 was nearly 30,000,000 bushels and it is safe to say that within ten years the wheat product will be nearly 100,000,000 bushels. The eastern portion of the State, when all the wheat lands are cultivated, is capable of producing about 120,000,000 bushels per annum, or say one-fourth of the present entire wheat product of the United States. The saving in cost to the farmer and the merchant in the shipment of this product by the lake instead of by salt water, would amount to an enormous sum.

In addition to the coal and wheat products the amount of lumber to be shipped from the lake would be very large.

There are also within 50 miles of the lake some of the best Bessemer iron deposits in the world. Already transportation has been nearly provided between the lakes and these deposits, and extensive works for the reduction of these ores are now being built upon the shores of the lake, and it is expected that these works and the mines will be in operation within one year from this time.

Summing up, it may be said that there is not a coal mine of any consequence in the State of Washington that can not more readily ship its product to Lake Washington than to the Sound. Neither is there any iron deposit whose product could not be more readily shipped from the lake. As a site for the establishment of the very extensive manufactures that will be required on the Pacific coast there is no point that begins to possess the advantages of Lake Washington. This is so not only by superior natural location but because of the inexhaustible supply of fresh water. If the construction of a canal were begun at once, it could not be completed before the developments in iron mining and manufacturing and in coal mining, and the wheat product, would more than justify the small expenditure required.

THE CHAMBER OF COMMERCE OF SEATTLE.

By E. O. GRAVES, *Vice-President.*

J. W. DODGE, *Secretary.*

COMMUNICATION OF MR. C. J. SMITH, GENERAL MANAGER.

PORTLAND, OREGON, *April 21, 1891.*

DEAR SIR: In relation to the business which this company would be likely to transact upon the shores of Lake Washington in case a canal was cut through from the waters of Puget Sound to Lake Washington, I would say:

This company is the owner of the Columbia and Puget Sound Railroad, a narrow-gauge road extending south and east of Seattle to the Newcastle Mine, a distance of

21 miles, and from the junction at Renton to Franklin Mine, a distance of 34 miles from Seattle.

There is located upon this road coal mines belonging to this company, known as the Newcastle Mine and Franklin Mine. In addition to these there is located upon the line of this railroad the Black Diamond and Cedar Mountain Mine. The entire output of these mines would find a shipping point upon Lake Washington in case a canal was cut through. The output of the mines is as follows:

	Tons.
In 1888, Newcastle Mine.....	84,000
Franklin Mine.....	177,000
In 1889, Newcastle Mine.....	67,000
Franklin Mine.....	90,000
In 1890, Newcastle Mine.....	130,000
Franklin Mine.....	74,000

Various causes have contributed to keeping the output of these mines very considerably below their average capacity. In 1888 there was a fire in both the Newcastle and Franklin mines, and in 1889 and 1890 the Newcastle Mine, owing to strikes, was shut down two months and the Franklin Mine four months. The estimated output of these mines, barring strikes, fires, or accidents, would be as follows:

	Tons.
Newcastle Mine.....	200,000
Franklin Mine.....	150,000
Black Diamond Mine.....	200,000
Cedar Mountain Mine.....	60,000
Total.....	610,000

All the output of these mines is transported over the railroad of this company and shipped from the coal bunkers of this company at Seattle, with the exception of the amount used for domestic purposes at Seattle. The amount of coal so used at Seattle would be about 75,000 tons per annum, leaving 535,000 tons for shipment. Owing to the difficulty with the teredo at Seattle, it is necessary to build these bunkers with copper-covered piles, and the shipments of the above mines are now made from coal bunkers which cost this company \$168,000. Bunkers sufficient to enable this company to handle this product from fresh water at Lake Washington could be built for \$50,000, and could be maintained much more cheaply than the bunkers at Seattle.

The class of vessels transporting this coal are steamers ranging from 1,000 to 2,500 tons capacity, with an average draft, loaded, of 19 feet. In addition to the coal shipped in steamers, it has been the custom of both this company and the Black Diamond Coal Company to charter sailing vessels ranging in capacity from 1,000 to 3,000 tons, with draft, loaded, of about 21 feet. This company owns or controls a fleet on the Pacific coast of about twenty steamers, ranging in capacity from 1,000 to 2,500 tons, and are now engaged in the coastwise business, with routes from Portland to Puget Sound points, and from Puget Sound points to Alaska. They have a departure of vessels averaging every four days, and in addition to the coal carried, do a very large merchandise and passenger business. It is probable that a considerable portion of this business would be done at the wharves on Lake Washington should this canal be cut through.

The Newcastle Mine of this company is located only a mile from the shores of Lake Washington, the Cedar Mountain Mine about 8 miles, the Black Diamond Mine about 16 miles, and the Franklin Mine about 18 miles. There would be a saving in distance in the carriage of coal to Lake Washington from Newcastle Mine of nearly 20 miles; from Cedar Mountain Mine of about 10 miles; from Black Diamond Mine of about 18 miles, and from Franklin Mine of about 14 over the carriage of coal to Seattle.

In addition to the mines already opened and developed, there are a number of prospects in this same region that would be opened and developed to a working output if the cost of transportation and wharfage charges were cheapened to the extent expected by the opening of service on the shores of Lake Washington.

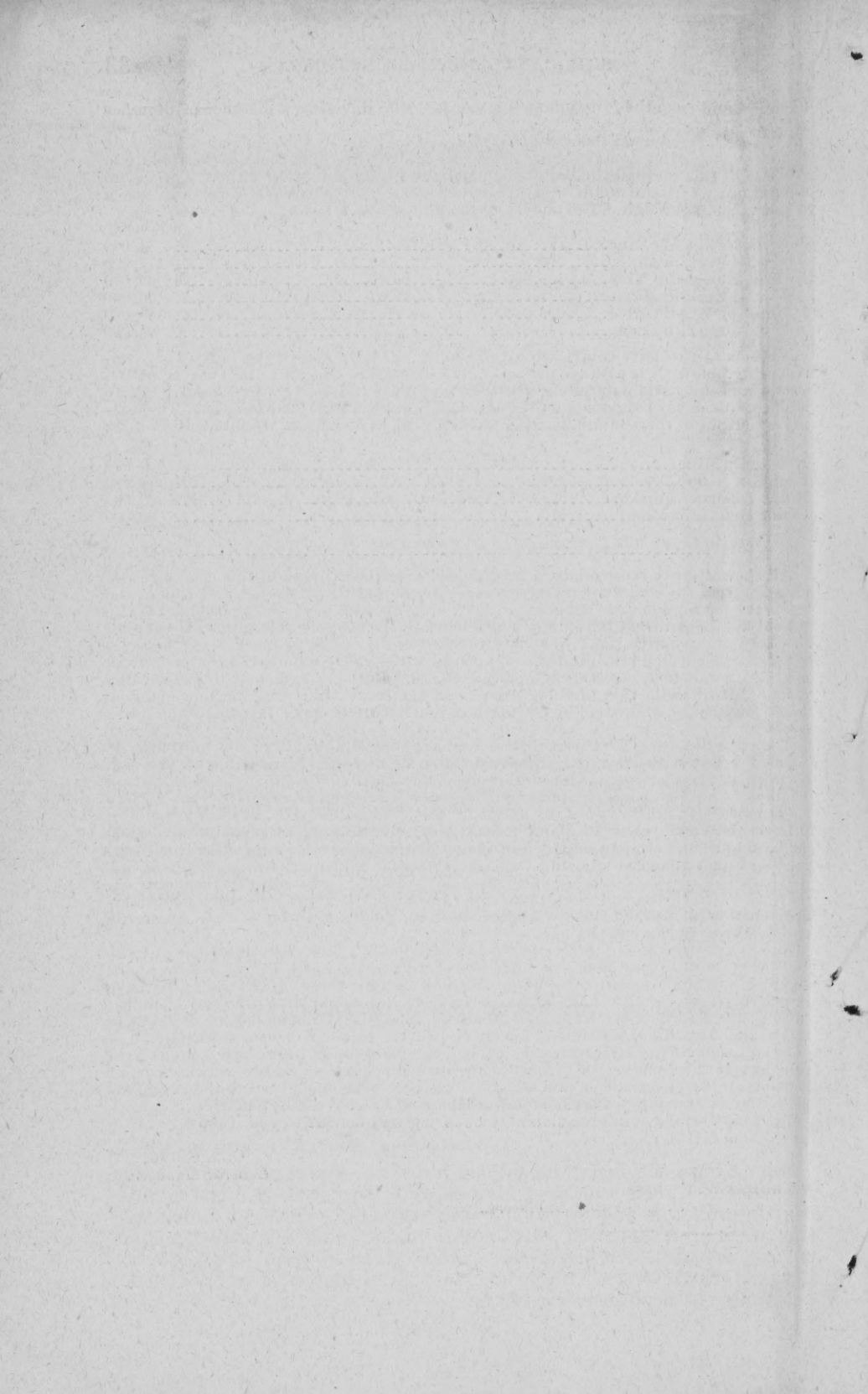
Trusting the above information may be of use and benefit to you, I am

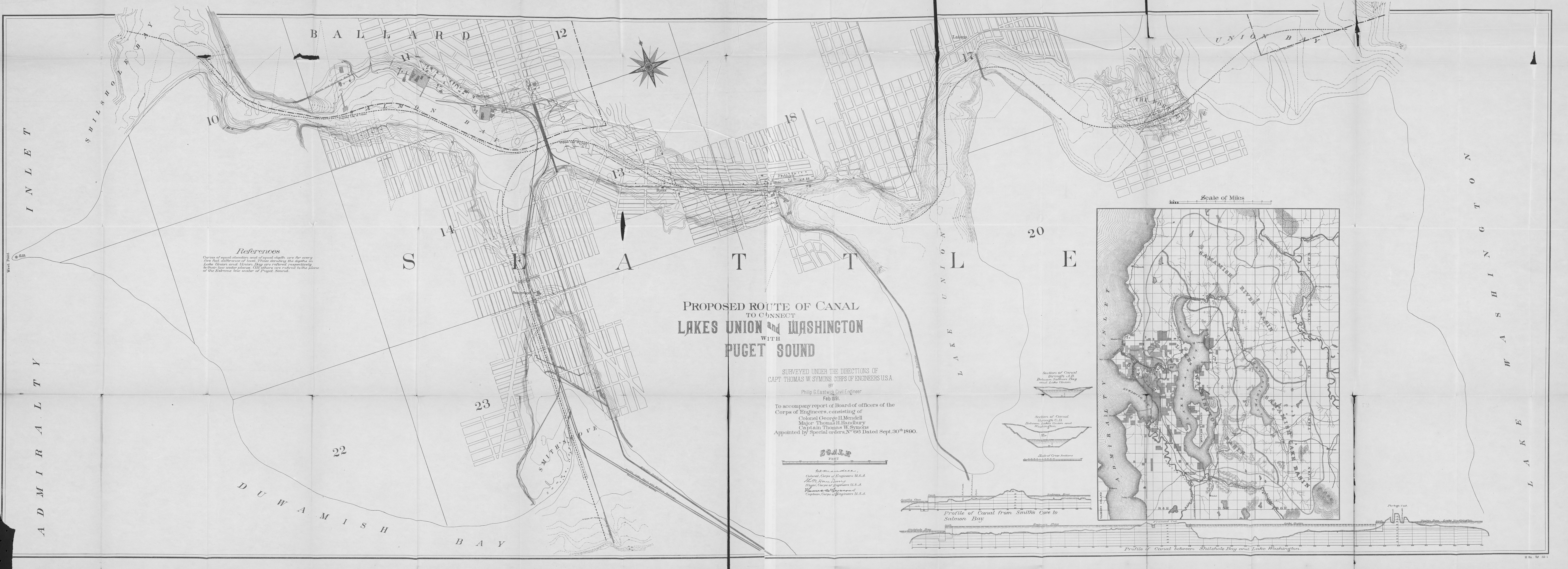
Yours, truly,

C. J. SMITH,
General Manager.

THOMAS W. SYMONS,
Captain, U. S. Corps of Engineers.

H. EX. 40—3





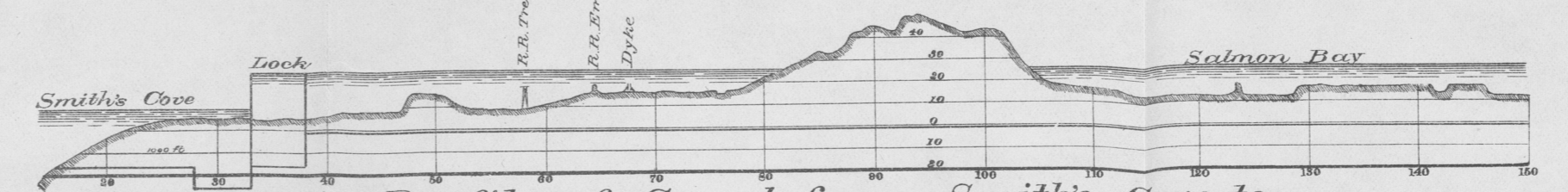
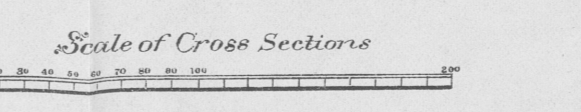
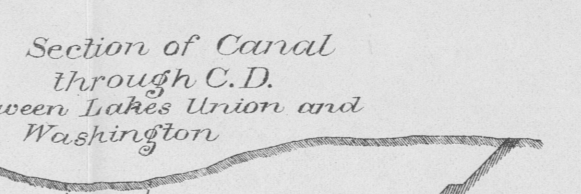
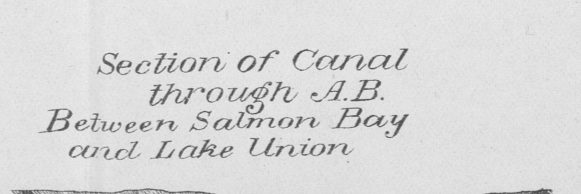
References
Curves of equal elevation and of equal depth, are for every five feet difference of level. Those denoting the depths in Lake Union and Union Bay are referred, respectively, to their low water planes. All others are referred to the plane of the extreme low water of Puget Sound.

**PROPOSED ROUTE OF CANAL
TO CONNECT
LAKES UNION and WASHINGTON
WITH
PUGET SOUND**

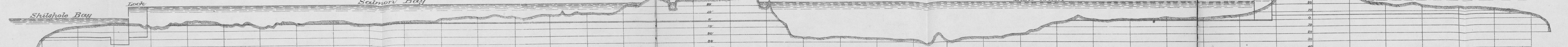
SURVEYED UNDER THE DIRECTIONS OF
CAPT THOMAS W. SYMONS, CORPS OF ENGINEERS U.S.A.
BY
Philip G. Eastwick, Civil Engineer
Feb. 1891.
To accompany report of Board of officers of the
Corps of Engineers, consisting of
Colonel George H. Mendell
Major Thomas H. Handbury
Captain Thomas W. Symons
Appointed by Special orders, No. 66 Dated Sept. 30th 1890.



Approved,
Colonel, Corps of Engineers U.S.A.
Philip H. B. Davis,
Major, Corps of Engineers U.S.A.
Thomas W. Symons,
Captain, Corps of Engineers U.S.A.



Profile of Canal from Smith's Cove to Salmon Bay.



Profile of Canal between Shilshole Bay and Lake Washington.

